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ABSTRACT

This guide contains background materials and ideas for vocational education teachers to use in planning learning activities on the metric system for their students. Organized into eight chapters, the book covers the following topics: overview of the metric system; program administration; metrics in agricultural education; in business and distributive education; in health occupations education; in home economics education; and in industrial arts, trade and industrial, and technical education. Each chapter includes an introduction; instructional strategies; standards for metrics in that field; information about tools, instruments, and equipment; sample teaching activities; and references and resources. The final chapter is an annotated guide to metric learning and teaching. (KC)

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Metric Planning Guide for Vocational Education

Prepared by
Vocational Education Sector Committee
American National Metric Council
in cooperation with
American Vocational Association.

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INTRODUCTION

Certain events and decisions within American industry and education in the past decade point to the possibility of increased use of the metric system in the United States. Several major public and private agencies have been organized to research the problems and opportunities involved in metric conversion: The United States Metric Board, the American National Metric Council, the United States Metric Association and the U.S. Department of Education Metric Education Program. Some specific evidence of metric change are perhaps appropriate:

1. All other major industrial nations have either converted to metric or are committed to conversion and are well along in their programs.
2. American auto producers are moving toward metric use. General Motors produces 27 out of 34 nameplates in metric units and other manufacturers have instituted conversion programs. Automobiles imported into the United States are predominently metric.
3. Many major soft drink companies market one and two liter bottles of their product. Wine and distilled spirits in the United States are sold in metric bottles.
4. Some of the design work for off-road heavy equipment is now in metric modules.
5. Most science education instruction is in metric units.
6. Several private sector committees have prepared conversion guides for their industries, including textiles, metals and threaded fasteners.

As the United States increases use of the metric system, vocational educators will have to plan metric learning experiences for their students. This must be done as a logical response to the needs of society and industry, inasmuch as vocational education programs are directed at preparing young people to enter the work force. While the pace of conversion in the various vocational areas will vary considerably, and teachers therefore may not be subjected to equal pressures to become involved, the profession should be prepared to meet this challenge effectively and economically.

The purpose of this book is to assist vocational administrators and teachers as they engage in this planning, so they can make intelligent decisions about the work that lies before them. The guide is organized into eight chapters, several of which deal with occupational areas identified by the American Vocational Association. This guide does not describe the metric needs for every conceivable job classification; instead, teachers must examine appropriate chapters and draw from them the information to be organized into their curriculum plans.

This is especially true for the technologies. For instance, a person who prepares mechanical engineering technicians or instrumentation technologists should study the sections dealing with metalworking, electricity and electronics and use this information to provide functional learning activities for students. However, the teacher will need to go beyond the constraints which size and finances impose upon this book and study the metric conversion information provided by trade associations and technical societies.

Each chapter of this book concludes with specific recommendations for further references and resources. These are indicated by numbers, which

correspond to the items listed in Chapter 8, *Metric Learning and Teaching Resources.* For example, a teacher of welding technology can learn a good deal from this guide, but it is also important to examine the technical guide prepared by the American Welding Society, Reference 56 in Chapter 8. Complete ordering information can be found in that chapter.

The preparation of the *Metric Planning Guide* was a joint undertaking of the Vocational Education Sector Committee of the American National Metric Council and the American Vocational Association (AVA), which acted as secretariat. The American National Metric Council is a private, nonprofit organization working with various sectors of the economy to plan and coordinate metric conversion in the United States. Committee members generally were selected with the advice and assistance of the AVA. Committee members are listed on the following page.

The committee wishes to express its gratitude to the following persons who reviewed sections of the document for accuracy and content and otherwise assisted in its development: Louis E. Barbrow, American National Metric Council; Forrest Bear, Department of Agriculture Engineering, University of Minnesota; Carol Bielefeld, Home Economics Consultant, Santa Rosa, Calif.; John L. Feirer, Department of Industrial Technology and Education, Western Michigan University; Franklin J. King, Industrial Education, University of Missouri; Muriel A. Kole, Health Occupations Education, New York State Department of Education; Catherine Leisher, Home Economics Education Association; and Lila Prigge, Department of Business and Vocational Education, University of North Dakota.

The committee is especially appreciative of the services of Michael Kenny, Editorial Director, Chas. A. Bennett Co., Inc., who was the manuscript editor.

The *Metric Planning Guide for Vocational Education* should prove to be a valuable aid in the metric planning efforts of vocational educators. The committee welcomes reader comments on this and future editions. Please address comments to the appropriate author at the address noted in this introduction.

Readers of this guide should clearly appreciate that metric conversion is a voluntary act and therefore different industries, or individual companies within an industry, may be proceeding at differing paces ranging from very active to little or no metric activity. It is important that educational efforts be coordinated with the pace of conversion. Teachers and administrators are encouraged to seek the guidance of state education officials before embarking on an exclusive or intensive metric program.

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CHAPTER 1

An Overview of the SI Metric System

John R. Lindbeck

The modernized metric system being promoted for world use is called the *Systeme International d'Unites* (International System of Units) or "SI." Americans are becoming aware of this advancement, as evidenced by the increasing use of metrics* in the business, industry, education and consumer sectors.

While SI is no more accurate than our customary inch-pound measure, a number of good reasons exist to recommend its adoption. First, it is *convenient* because it is a purely decimal or base ten system, using prefixes to create larger or smaller multiples of units. Second, it is *coherent* in that there are direct one-to-one relationships among units, without the introduction of factors such as 550, 760 and so on. Third, it is *unique* as there is only one unit for each measure, regardless of the branch of technology to which it is applied. Fourth, it is a *universal* system. SI is truly international, and with very few exceptions every country in the world is using or planning to use it.

While there are many advantages that recommend SI, the most compelling reason for us to elect is that in measurement the United States must have commonality with the rest of the world. Examples of these principles of coherence, uniqueness and convenience will be shown later in this chapter and throughout the book.

Any discussion of measurement systems must include the elements of theory, practices and standards. These are described in the paragraphs that follow.

SI METRIC THEORY

The basis for SI is a series of seven base units and two supplementary units. These are explained in Figures 1-1 and 1-2. It is important to note that, of these measures, the length, mass and temperature units are the most important for practical use. The remaining base and supplementary units are largely unchanged for common use or are utilized in technical computations.

The base and supplementary units can be combined to form a broad range of useful, derived units. See Figure 1-3. Some of these derived units have been given special names for the sake of convenience. For example, the unit of pressure is the pascal, which is one newton per square meter. Other derived units are given in compound form for such measures as the pascal second for dynamic viscosity, and the watt per meter kelvin for thermal conductivity. These latter examples further point to the desirability of giving common derived units special names for convenience.

The relationships of these units are graphically displayed in the accompanying chart, Figure 1-3. The principle of coherence is exemplified by studying the unit of energy, which is the joule. It is expressed as, "One newton times

*Whenever the word "metric" appears in this book, what is implied is SI plus those units authorized for use with SI.

Figure 1-1
Chart of the Seven SI Base Units

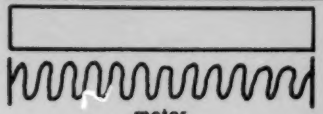
Unit	Symbol	Description
 meter	m	The meter is equal to a specified number of wavelengths of the light given off by the atom krypton-86. Commonly used related measures are the kilometer (km) = 1000 (one-thousand) meters; the centimeter (cm) = 0.01 (one-hundredth) meter; and the millimeter (mm) = 0.001 (one-thousandth) meter.
kilogram	k	The kilogram is equal to the mass of the international standard kilogram cylinder. The kilogram is often used to measure what we commonly call weight. Common related measures are the gram (g) = 0.001 (one-thousandth) kilogram; and the milligram (mg) = 0.001 (one-thousandth) gram.
second	s	The second is equal to a specific number of movements of the cesium atom in a device known as an atomic clock. A common related measure is the millisecond (ms) = 0.001 (one-thousandth) second. The minute, hour, day, and year are also used, although they are not SI units.
kelvin	K	The kelvin is equal to a specific fraction of the temperature at which water exists as a solid, liquid and vapor. This is called the triple point of water. The kelvin is used mainly for scientific measurements. For practical, everyday purposes, the degree Celsius (°C) is used. Water boils at 100 °C, and it freezes at 0 °C. The Celsius scale is equal to, but replaces, the old Centigrade temperature scale.

Figure 1-1 (continued)
Chart of the Seven SI Base Units

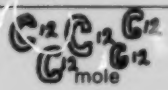
ampere	A	The ampere is equal to the current in two parallel wires one meter apart, that results in a specific force between the two wires. The milliampere (mA) = 0.001 (one-thousandth) ampere, is a common related measurement.
candela	cd	The candela is equal to the light intensity of a green source of specified character and radiant intensity.
 mole	mol	The mole is a unit of measure of a number of particles compared to the number contained in a specific amount of carbon. This unit is used mainly in special scientific measurements.

Figure 1-2
Chart of the Two SI Supplementary Units

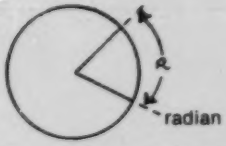
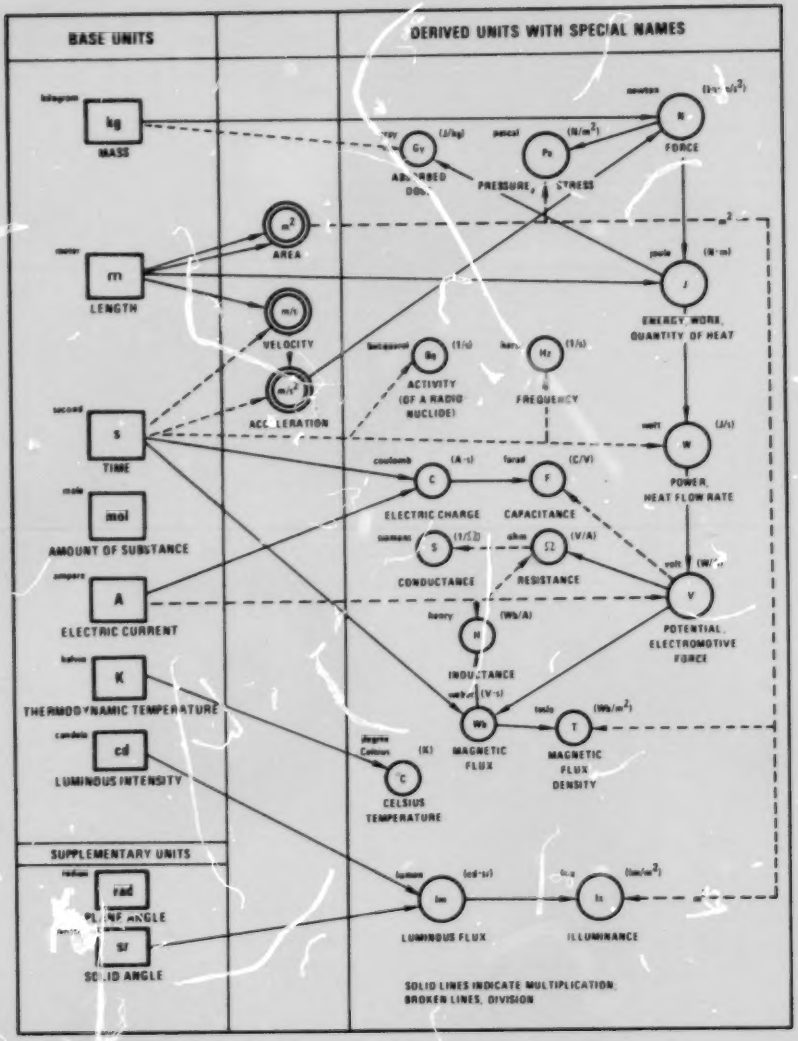
Unit	Symbol	Description
 radian	rad	The radian is the angle between two radii of a circle that cut off on the circumferance an arc equal, in length, to the radius of the circle. The radian is used primarily in scientific calculations. For practical measurement, the degree, minute, and second of angle can be used, even though they are not SI units. The decimalized measure of degree of angle is recommended in most cases.
steradian	sr	The steradian is a solid angle that, with its vertex at the center of a sphere, cuts off on the surface of that sphere an area equal to that of a square with sides equal to the radius of the sphere. Its use is primarily scientific.

Figure 1-3
Relationships of Common SI Units



one meter equals one joule." The joule uniquely replaces the BTU and the calorie in their several forms, plus the erg, the therm, the electronvolt and several other customary energy units. Note there are no multipliers, constants or special factors when expressing the joule. Further examination of Figure 1-3 will reveal many other examples of the principles of coherence and uniqueness.

The decimalization feature of the metric system simplifies calculations. Equally convenient are the prefixes that may be applied to units to indicate their multiples and submultiples, as shown in Figure 1-4. For example, instead of saying "1000 meters," the prefix *kilo* can be applied to the unit *meter* to form the word *kilometer,* which of course means 1000 meters. Similarly, the term millimeter can be used in place of 1/1000th of a meter, making both computations and descriptions easier.

Select and Master the Necessary

At first glance, this comprehensive series of base, supplementary, derived and compound units, plus the complete chart of prefixes, represents a formidable amount of measurement information to be learned and used. However, it should be reassuring to recognize that each technology has its own peculiar set of common units and prefixes. For example, in a cabinetmaking shop the most common units will be the meter and millimeter as the measures of linearity, and the square meter for area. Therefore these are the primary metric measures to be taught and used in that technical area.

Similar delimitations can be made for other technologies. The point is that while SI is quite complex and extensive, the user need select only those units and prefixes that apply to a technology, just as is done at present with the inch-pound system. Thus the task is not nearly as complicated as it appears; select and master only what is necessary.

METRIC PRACTICES

In order to make SI truly universal and to facilitate international communication, a comprehensive set of rules has been developed, which governs the use of the system throughout the world. These rules appear in metric practice guides, several of which are listed in Chapter 8 as references 4, 5, 6 and 7. They should be studied. However, it may be helpful to review a few of the more common and useful practices here. See Figures 1-1 through 1-4 for related data.

1. The first letters of unit and prefix names are not capitalized, except when they begin sentences or appear as titles in charts. The one exception is the degree Celsius.

2. The short forms for metric units are called symbols, not abbreviations. The first letter of a symbol is capitalized only when the name of the unit is derived from the name of a person. Other symbols are lower case, with the exception of the symbol for liter, which is L. Periods are never used after symbols, except at the end of sentences.

3. As seen in Figure 1-4, the first five prefix symbols are capitalized and all the rest are lower case. It is important to abide by this rule of practice because, for example, the symbol for giga is G, while the symbol for gram is g, and confusion could arise if an improper case is used.

Figure 1-4
Table of SI Unit Prefixes and Related Data

Multiplication Factor	Prefix	Symbol	Pronunciation (USA) (1)	Term (USA)	Term (Other Countries)
1 000 000 000 000 000 000 = 10^{18}	exa	E	as in Texas	one quintillion (2)	one trillion
1 000 000 000 000 000 = 10^{15}	peta	P	as in petal	one quadrillion (2)	one thousand billion
1 000 000 000 000 = 10^{12}	tera	T	as in terrace	one trillion (2)	one billion
1 000 000 000 = 10^{9}	giga	G	jig' a (a as in about)	one billion (2)	one milliard
1 000 000 = 10^{6}	mega	M	as in megaphone	one million	
1 000 = 10^{3}	kilo	k	as in kilowatt	one thousand	
100 = 10^{2}	hecto	h (3)	heck'toe	one hundred	
10 = 10	deka	da (3)	deck' a (a as in about)	ten	
0.1 = 10^{-1}	deci	d (3)	as in decimal	one tenth	
0.01 = 10^{-2}	centi	c (3)	as in sentiment	one hundredth	
0.001 = 10^{-3}	milli	m	as in military	one thousandth	
0.000 001 = 10^{-6}	micro	μ	as in microphone	one millionth	
0.000 000 001 = 10^{-9}	nano	n	nan' oh (nan as in Nancy)	one billionth (2)	one milliardth
0.000 000 000 001 = 10^{-12}	pico	p	peek' oh	one trillionth (2)	one billionth
0.000 000 000 000 001 = 10^{-15}	femto	f	fem' toe (fem as in feminine)	one quadrillionth (2)	one thousand billionth
0.000 000 000 000 000 001 = 10^{-18}	atto	a	as in anatomy	one quintillionth (2)	one trillionth

(1) The first syllable of every prefix is accented to assure that the prefix will retain its identity.

(2) These terms should be avoided in technical writing because the denominations above one million and below one millionth are different in most other countries, as indicated in the last column. Instead, use the prefixes or ten raised to an integral power.

(3) While hecto, deka, deci, and centi are SI prefixes, their use should generally be avoided except for the SI unit-multiples for area and volume and nontechnical use of centimeter, as for body and clothing measurement.

Regarding the selection of prefixes, while hecto, deka, deci and centi are approved SI prefixes, their use should be avoided except for special cases. The centimeter will be used for body and clothing measurement and some appliances, but never for technical measures. For example, the length of a board or a metal part will be measured in millimeters, not centimeters. Distances will never be measured in hectometers, dekameters or decimeters. These prefixes are important in educational theory as one learns the relationships and decimal separations of units, but they will never be used computationally.

Furthermore, the hectometer is useful and necessary in describing the hectare as a square hectometer, and the decimeter is important in defining the cubic decimeter as one liter. Remember that the use of these prefixes is quite limited. There will be no commercial use of hectoliters, dekaliters or deciliters as they relate to volume.

4. Always leave a space between the numeral and the unit symbol to which it refers, for example, 2 mm. However, for temperature measure, no space is left between the numeral and the degree symbol. The symbol for degree Celsius is °C. This is an inseparable symbol with no space between the two parts or the accompanying value, for example, 20°C.

5. The decimal marker is a dot on the line. In some countries a comma is used, in others a raised dot.

METRIC STANDARDS

The third element of measurement systems deals with material, product and engineering standards. These are developed by the International Organization for Standardization (ISO) for worldwide use and are occasionally modified by countries for special reasons. Specific standards relate to each of the technologies.

For example, in the area of woodworking and building construction there are standards for lumber, panel sizes, roofing roll width, weights or masses of sacks of concrete, and volumes of paint and finishing containers. In home economics and distributive education there are standards for clothing, shoe sizes, fabric widths and lengths and for kitchen measuring utensils. It is important for instructors in each technical area to become familiar with the standards that relate to their areas of specialization. Several examples of these standards appear throughout this book, and others can be found in Chapter 8.

This brief treatment of the basics or fundamentals of metric measurement details some of the highlights so that the reader may become familiar with the system. Further specifics on metric theory and usage can be found throughout this book.

REFERENCE AND RESOURCES

The following references will be helpful in acquiring further information regarding SI theory and practice: 3-7, 15, 25, 26, 27, 51, 53 and 89. (See Chapter 8.)

CHAPTER 2

Program Administration

William P. Spence and Clarence H. Preitz

Vocational administrators engaged in metric conversion activities should approach the task as they would any other educational challenge they have faced in the past. Metric conversion is a major program modification requiring planning and the subsequent mustering of resources and talent. This chapter deals with the important elements of planning.

INITIATING THE PROGRAM

The central educational administrative officers and members of governing boards must be solidly behind any program to infuse the metric system into the institutional curriculum. They must understand what is required of them, the faculty and the students to ensure a successful program. A formal, written declaration of commitment should be the first step in initiating a program leading to total metrication. The declaration should include a statement of support, a target date for completion of the metric program, an indication of the significance of the program and the advantages it will offer the school, the students and the employers of the graduates. The document should be signed by appropriate administrative officers and governing board members.

This statement of commitment should be given proper circulation so everyone is aware of it and its importance.

The Metric Committee

The development of a plan to introduce metrics in the curriculum is the work of a special metric committee. This committee should have broad representation of those who will be involved in, or affected by, the process. Faculty, students, administrative officers, governing board members and industrial advisory committee members should be included. However, it should not be too large or it will become cumbersome. Members should be interested and willing to participate.

Since the committee will function over a period of years, a staggered plan for changing members must be developed. Each year certain members will complete a term of service and some new members will be introduced. This is important because new ideas are generated by new people, and because the total involvement of those affected is expanded, leading to greater acceptance and success.

The Metric Coordinator

The institutional administration should select a coordinator who should also serve as chairperson of the metric committee. Careful attention should be given to the selection of this person because the metric coordinator is going to be the key to success. The coordinator should be knowledgeable in the metric system, aware of its importance in the educational program and able to organize, write and work well with people.

The administration should give the coordinator released time from regular duties to handle these additional responsibilities, and a special budget should be established for the metrication project. Even the most competent person cannot succeed without ample time and money.

The Program Objectives

The objectives for the program must be clearly stated. Typically, the program should aim to prepare faculty to understand, use and teach the system, to include metric units in their courses, to prepare teaching aids, to select metric teaching materials and to secure tools and equipment. The objectives are developed by the metric committee and should be publicized.

The Evaluation Plan

Once the objectives have been prepared by the committee, it is necessary to write a plan to evaluate the success of the project. Evaluation is more productive if it employs such measureable units as faculty scores on metric tests, student test scores, program costs and data from employers. See *Review of Progress* later in this chapter.

The Action Plan

The metric committee should establish a plan of action to cause metric conversion to take place. The plan can take many forms, depending upon the local situation and past experiences. Following is a suggested outline.

1. *Set target dates for accomplishing the various parts of the plan.* Be ready to adjust these if it becomes clear that more or less time will be needed.

2. *Select or prepare those who will do the training.* These might be local people or consultants from neighboring industries or universities. Whoever they are, they should be up-to-date on the accepted metric practices.

3. *Prepare a metric awareness plan.* This is basically a public relations effort, and its importance should not be underestimated. There is going to be resistance to accepting the use of metrics, simply because many people are afraid of what they do not know. This group will include faculty, students and parents. The need is to convince people that the metric system is easy to understand and that its use has concrete rewards.

The metric committee can help dispel fears by using basic public relations techniques. Brochures can be purchased in quantity and distributed. Bulletin board displays, guest speakers in meetings of the faculty, at school assemblies and at parent-teacher associations, and articles in both the local newspaper and the school paper can help reach the intended audiences. Emphasize the units that most people will deal with first and those with the greatest number of applications. Do not be vague—give specific examples of the use of the metric system that is already taking place in the United States.

4. *Develop training programs for the faculty and administration.* Be selective, for all aspects of the metric system need not be taught. An analysis of the program activities will reveal those metric units essential for classroom instruction. Teach only those that will be used in each course. The closer the teaching is to the application, the more likely the material will be learned and retained.

A simple *needs matrix* can be devised to assist with the selection of common and special metric material to be taught. Figure 2 offers an example of such a matrix. The needs matrix clearly depicts which units need to be taught to all

faculty and students and which appear only in selected areas and should be presented there.

5. *Administer the training sessions for faculty.* The goal is to provide the training when it is needed for use in classes. Coordinate the training with a faculty plan to begin introducing metrics in classes. The method of delivering the faculty inservice instruction will vary with the local situation. For example, a formal class might be taught in the evening, which could be offered by extension at a regional university for credit. Self-instructional materials might be made available. Audio-tutorial programs could be used so faculty can study in their free time and review the material as often as necessary. These and other delivery systems need to be planned as part of the training program. See *Preparing the Faculty* later in this chapter.

6. *Acquire the metric tools and materials needed for each instructional program.* These can range from inexpensive items such as metric templates in drafting to the more costly conversion of machine tools. Not all of these tools will be needed at once, so plan a carefully scheduled purchasing program to supply the items when needed.

7. *Plan the development of instructional materials for faculty use after commercial materials have been carefully evaluated.* This includes texts and other purchased media as well as teacher-developed visuals. The faculty will need to write instruction sheets showing metric applications to their areas of specialization. Examples of these appear throughout this booklet. Fit these into the time schedule established for providing metrics in the instructional program.

8. *Develop the criteria to be used to monitor the program.* Regularly check to see that training is progressing properly and that learning is taking place. Make certain the objectives are being met and that the program is on schedule. Periodically reevaluate the plan and strengthen any parts of it that seem to be weak.

9. *Organize a plan for continuing the metric education program for several years.* A one-time program will initiate the plan, but that alone will not make certain that the plan will thrive and improve. A yearly series of activities is necessary to promote the use of metrics, to teach the system to faculty and to insure its use in classes. Because these activities will change in direction and emphasis, the metric committee needs to remain active over a period of years to guarantee a thorough assimilation of the metric system into the curriculum.

THE COSTS OF CONVERSION

There have been several research investigations into the costs of converting industrial education equipment to metric. The results of these studies contain reliable figures concerning the changeover for a limited number of program offerings. One such study of conversion costs for vocational education was made in the Province of Alberta, Canada, for the career fields of visual communications, mechanics, construction and fabrication, electricity/electronics and personal services. The results of this study show the highest costs to be for automotive and machine shops, which together accounted for approximately 65 percent of the total. Drafting and woodworking were among the least expensive areas to convert.

The goal of metric conversion for vocational education should be to make the change on a least-cost basis; that is, to phase in the appropriate items as

Figure 2
Needs Matrix

	Administration	Drafting Technology	Nursing	Home Economics	General Business	Other
Seven Base Units	X	X	X	X	X	
Length—overview	X	X	X	X	X	
Length—depth		X	X	X		
Mass—overview	X	X	X	X	X	
Mass—depth		X	X	X		
Time	X	X	X	X	X	
Electric current		X	X	X		
Thermodynamic temperature						
Temperature, Celsius	X	X	X	X	X	
Amount of Substance—overview						
Luminous intensity—overview				X	X	
Symbols—overview	X	X	X	X	X	
Symbols—depth		X				
Derived units--overview	X	X				
Derived units (specific)						
Area		X	X	X	X	
Volume		X	X	X	X	
Velocity		X				
Acceleration		X				
Luminance				X		
Frequency						
Force		X				
Energy						
Power						
Pressure		X				
Two supplementary units	X	X	X	X	X	

A typical matrix for analyzing needs.* This is an example only and not intended to be *all* inclusive.

*Further information on needs analysis can be found in Dr. Arvon D. Byle, "An Occupational Analysis Model to Determine Metric Measurement Competencies for Pre-service and In-service Education as Applied to the Graphic Arts Industry." (Unpublished doctoral dissertation, Michigan State University, East Lansing, 1975.)

they are needed. These costs should be the function of good management and sensible planning as well as good timing.

Elements of Cost

There are many variables to be considered when identifying realistic conversion costs in vocational education programs. Two key variables are (1) proper planning and scheduling and (2) equipment modification and replacement. Unless these two factors are properly considered, the costs of conversion will be higher and the rewards will be reduced. One thing is certain—the longer the delay in purchasing metric learning equipment, the greater the cost, because of inflation for each year of postponement. It will be most troublesome to a school or district if the cost of metric conversion is underestimated or the process of conversion is deferred.

The elements of costs associated with metric conversion are:

1. Modification of machines (including the parts and labor).
2. Replacement of obsolete machines.
3. Replacement of appropriate hand tools and measuring devices.
4. Preparing teacher-designed instructional materials and devices.
5. Purchasing audio-visual materials.
6. Establishing a metric resource library. See Chapter 8.
7. Securing consultants to conduct "hands-on" workshops or seminars.
8. Retaining advisors to identify those machine or hand tools that need to be modified or replaced.

Elements one through six relate directly to conversion costs and are most significant. Items seven and eight are variables related to the general planning scheme and faculty/staff expertise.

TOOLS AND EQUIPMENT

Vocational education teachers making the change to metric units must make a range of software and hardware changes in their teaching environments. In the conversion to metric, some of the major pieces of equipment that are in these facilities have to be changed rapidly, some slowly and some not at all.

Under such a plan one should change only that equipment it is economically feasible to change. Most machine tools can operate equally well in either customary or metric units, but they represent a major problem during metric conversion. Generally speaking only the setting dials need to be changed or altered. For this purpose conversion dials which read out in millimeters can be used. Numerically controlled and digital numeric controlled machines can be programmed for metric cutting. Lathes generally require that the lead screw be changed for cutting metric threads.

Machine tool modification can be placed in one of three categories:

1. Tools with a useful remaining work life should be rapidly refitted with modification kits to make them capable of working in metric units.
2. Old tools with a short remaining life should not be modified. Rather, plans should be made to replace these items with equipment that has metric capabilities. Equipment that is metric sensitive should be purchased on a "phase-in" basis.
3. As older equipment begins to depreciate and is classified as obsolete, it should be replaced with tools that have metric capabilities only.

The two significant questions that must be answered before modifying or purchasing equipment are: (1) What is the useful life cycle of each machine in the shop? (2) What must be done to make the machine capable of producing parts in metric units? After these questions have been answered, teachers must determine the order in which their machine tools should be modified or replaced. Experience in other industrial nations that have recently converted to the metric system shows that the process of replacement or modification should be gradual. The newest equipment should be given first priority inasmuch as it will have the longest work life. With careful planning during the transition period, conversion cost can be kept to a mininum.

In determining whether to modify a piece of existing equipment or to purchase a new piece, adhere to the rule of reason which suggests that one should not purchase unless other benefits outweigh any metric-related disadvantages.

Measurement-sensitive tools, such as bench rules, micrometers, vernier calipers and torque wrenches, should be replaced with tools that are graduated in metrics only. The costs of these new tools, as well as the costs of modifying or replacing machine tools, often can be charged to the replacement budget, not to metric conversion costs.

PREPARING THE FACULTY

Since local situations vary greatly, the metric coordinating committee should consider a variety of ways to deliver metric education. In most cases more than one approach or technique will be needed to reach all of the faculty.

Following are some approaches that can be effective:

1. Use a local faculty member to teach specially planned metric workshops. This individual could be from a vocational or industrial area or from mathematics or the sciences. Someone from a local industry who is qualified could be used to advantge. Such a workshop could concentrate on the material needed in the various vocational areas and emphasize practical applications.

2. Arrange for continuing education courses to be taught by faculty from regional colleges or universities. These can be for college credit or for continuing education credit. Vocational and industrial teachers can use this credit to renew their teaching credentials.

3. Consultants can be brought to the campus to present two- or three-day seminars. These seminars can be on metrics in general or on specialized applications in various vocational areas. Consultants can also be used to initiate the development of curriculum and teaching materials.

4. The administration can provide funds for the instructional media staff to prepare metric materials for teacher education and for classroom use.

5. Speakers are available from organizations such as the American Industrial Arts Association. These individuals can be used to help the faculty understand the importance of metric conversion and to present technical applications.

6. There is a considerable body of published materials available. Care should be exercised to use only those that have been carefully screened and are known to be correct. Appropriate manuals, charts and manufacturers' catalogs are invaluable to the education of the faculty.

THE REVIEW OF PROGRESS

Regularly review the progress that has been made toward meeting the goals of the plan. Those who are responsible for portions of the program can make

progress reports. Goals not met need to be reviewed by the metric committee and some form of action taken. For example, a person may have simply failed to do what was expected and may need counsel. A goal may have been too ambitious or vague and thus should be rewritten. Recommendations for what should happen up to the next review period should be written and disseminated.

The actual review will have to take a variety of forms because the actions to be taken are of different types. For example, data concerning faculty preparation could include factual information such as the number receiving preparation and the units actually covered. The quality might be checked by reviewing the scores of the tests taken by teachers after they finish a class. The review committee might examine the prepared course outlines and curriculum materials and judge the quality of the work accomplished. A report detailing the acquisition of metric tools for the school laboratories should be written. Costs for the period of the next report should be estimated and funds set aside to accomplish the next step. These and other such activities will comprise the regular review.

Periodic Updating

The task is not complete once a faculty has completed the original program of preparation and met the established goals. The situation should be reexamined regularly. New short and long term goals may need to be set. The faculty will need to have basic skills reinforced by continued educational experiences. They should be brought up-to-date as changes occur in the metric system and new standards are accepted. The metric committee should continue to initiate action and monitor progress until conversion has been achieved.

REFERENCES AND RESOURCES

Some references that will be especially valuable for administrators and planners are: 1, 4, 16, 18, 22, 26, 28, 49, 82, 84 and 86. (See Chapter 8.)

CHAPTER 3

Metrics in Agricultural Education

Ferrell M. Bridwell

INTRODUCTION

As our nation gradually moves toward conversion to the International System of Units (SI), it is imperative that leaders in the field of agriculture and agribusiness keep pace with this trend. The transition to metrics will affect all vital areas of agriculture such as scientific research and experimentation, production agriculture processing, storage and distribution of the products. Educators in vocational agriculture must develop goals for incorporating metric activities into the secondary and postsecondary curricula that will provide students with practical metric learning experiences.

The vocational agriculture instructor will play a major role in helping farmers and other adults in the local community to understand metrics as it applies to the individual's business or job situation. This can be accomplished through the young farmer/adult farmer organized classes or individually during on-farm visits. Instruction for adults will be especially important in the areas of fertilizers and pesticides as the successful use of each is often dependent upon very accurate measurement. While this chapter will not address adult education in agriculture as such, the vocational agriculture teacher must be prepared to offer practical and meaningful assistance as needs and oppportunities arise.

The field of agriculture is very diverse. It cuts across many agribusiness and industrial areas and is dependent upon these areas for production machinery, processing machinery, feed, chemicals and building materials. As the industrial sector produces more and more metric-sized materials, agriculture will necessarily become more metric.

Agribusiness will continue to make progress in metric conversion, while farming will probably lag behind. This is likely, in part, because gross farm output or net profit will not be changed by metrics. In addition, the commodities produced by farmers are frequently sold on the basis of weight, and the change from the inch-pound system can occur after it leaves the farm.

Professionals in agriculture should encourage a cooperative effort involving farmers or farmer organizations, agricultural agencies and educators to seek ways of facilitating metric conversion in agriculture.

INSTRUCTIONAL STRATEGIES

Since metric conversion is a gradual process, it is not realistic to attempt to turn out metric "experts" in agriculture. Rather, one should strive to generate interest through well-planned and stimulating metric activities, relating to things familiar to the student. The activities should be designed to enhance mental perception of metric units by helping the learner to acquire an easily remembered set of mental references.

For example, an average door is approximately 2 meters (m) high, and a hectare (ha) is approximately the size of two football fields side by side. Many

metric resource materials contain excellent examples. The set of mental references might include a person's mass (weight) in kilograms (kg) and height in centimeters (cm), to aid the individual's perception of metric units. Also helpful is exeperience in using simple measurement devices such as meter sticks, scales and thermometers. The teacher should help each student compile a set of referents to aid in developing interests in metric measures.

Once the student has learned to work with basic devices such as the meter stick and the Celsius thermometer, and has developed a set of mental references, the teacher should provide experiences in estimating. This can be accomplished by having the student estimate the metric unit values of objects which are easily accessible during the instructional period. The student should be asked to estimate the units, record the estimate and then take the actual measurement and determine the differences. After a few exercises the students should become proficient in estimating units within a reasonable degree of accuracy while, at the same time, receiving a high degree of self-gratification. These hands-on experiences allow a level of understanding that is often absent in purely theoretical settings.

It is not essential to provide experience with all metric measurements, as the student is more likely to maintain interest if the study involves only those units that will be used in the job situation or in daily living. For example, in measurements concerning mass, the gram (g) and kilogram (kg) should be the major thrust of instruction. Later, for example, if the situation dictates use of the metric ton (t), it would be more easily learned and understood once the gram and kilogram have been mastered.

The introductory activities should give the students a feel for the broad range of metrics by providing practical experiences in linear, area, volume, mass and temperature measures.

Once the student has acquired a feel for the basics of metric measurement, time should be allotted for practical application to the agricultural area for which training is being provided. This can be done as a unit or integrated into various learning modules throughout the entire year. In either case, it is important that the instruction involve practical application and that the student master one concept before moving to another.

Conversions from the inch-pound units to metrics should be kept to a minimum. Conversion between the systems might be useful in teaching replacement values and relationships or to illustrate that such conversions are sometimes necessary, if time consuming. The necessity for conversions is one of the major problems our nation encounters on the world market where measurements are based on SI metrics. Such conversions are expensive in terms of the monetary and human resources needed to implement trade with other countries.

Teachers of vocational agriculture should be leaders in promoting the use of metric measurement in the agricultural sector. This includes the need for inservice training designed to afford teachers an opportunity to become competent in metrics.

Each state should develop strategies for training agriculture teachers in the use of metrics and incorporate these strategies into the master plan for inservice training. The initial step might be to offer training programs for teacher educators, members of the Vo-Ag supervisory staff and other state department personnel. This would serve to help these groups feel comfortable about

metrics before they become involved in the development of a statewide inservice program for teachers.

Strategies for teacher inservice in metrics should focus on training which will be interesting, include incentives such as certification credit and reach the maximum number of teachers. Specific activities should be organized in much the same manner as those for students, with exercises designed to help the individual to "think metrics," utilizing hands-on activities before emphasis is placed upon more complex problem-solving activities. *Remember*, the degree to which teachers will incorporate metrics into their instructional program will depend upon their confidence in their own understanding of metrics and their belief in the importance of sharing this understanding with their students.

STANDARDS

While there are few metric standards for agriculture at present, one is especially worth noting. The American Society of Agricultural Engineers has adopted a practice guide that outlines the preferred metric units for use in agriculture. (See Reference 30, Chapter 8.) However, as the nation moves closer to metric conversion, more and more standards will be developed to insure consistency throughout the industry. These standards will be issued by the appropriate standards agencies based on decisions of the International Organization for Standardization and the American National Standards Institute. Professionals in the agriculture sector must be prepared to provide their assistance as needed.

Agriculture will need to modify some of its traditional standards to simplify calculations. For example, a cord of timber occupies a volume of space 4 feet high, 4 feet wide and 8 feet long, and is equivalent to 3.84 cubic meters (m^3). Standards will probably be issued to redefine the cord in terms of measurements that reflect whole metric integers. Some organizations such as the National Forest Products Association are working toward the adoption of standards to be used throughout the industry and have suggested metric sizes for plywood and board width. The teacher should seek out such organizations and ask for information as it becomes available.

The standards information presented in Chapters 4, 6 and 7 have applications for agriculture and should be studied.

TOOLS, MACHINES AND EQUIPMENT

Each year, more and more tools and equipment become available in metric specifications, and the teacher should begin including metric-sized items in the annual equipment purchase. Gradual conversion will make it possible to spread costs over a period of years and to prepare a replacement schedule for present equipment as it becomes obsolete or to modify selected equipment items as parts become available.

To provide students with important basic experiences, agriculture teachers should secure some of the less expensive items now, and plan meaningful activities that allow full use of the items. The following is a suggested list of tools and equipment needed to provide basic experiences:

1. *Linear/Area*—Meter sticks, metric rules (300 mm), metric tape (100 m), metric micrometer and feeler gauges.

2. *Volume*—Metric spoons (1 mL—25 mL), dry measure (50, 125, 250 mL), liter box and beakers (50 mL—1000 mL).
3. *Mass*—Kilogram scale and balance scale with mass piece set.
4. *Temperature*—Celsius thermometer.

Other equipment and/or devices should be secured as needed for specific measurements used in actual job performance. For example, special inside micrometers are needed by agricultural mechanics as they evaluate engine blocks for proper piston bore and ring set. See Chapters 4, 6 and 7 for metric equipment related to agriculture.

SAMPLE TEACHING ACTIVITIES

There are eight instructional areas for agricultural career preparation, the first seven of which are treated in this section:

1. Agricultural Production
2. Agricultural Resources
3. Forestry
4. Agricultural Mechanics
5. Horticulture
6. Agricultural Products
7. Agricultural Supplies
8. Other Agriculture.

All areas will be affected by the transition to metrics, and the instructor will need to incorporate appropriate learning activities and/or problems into the instructional outline.

The sample problems included in this section are designed to help the teacher *get started* in the development of metrics activities. Activities, of course, will have to be developed according to local needs and conditions. Availability of funds, teacher competencies, student readiness, local acceptance or support and community needs will all affect what can be accomplished. Yet, regardless of local conditions, one thing is certain: every teacher can provide students with training in metrics, by using personal experience and creativity to design high-interest activities, which are appropriate for specific students and which complement the instructional program.

Agricultural Production

1. Provided 1 cubic decimeter (dm^3) or 1 liter of several different feed grains, estimate the mass (weight) of each in kilograms (kg). Take the actual weight and record the differences. What would one cubic meter (m^3) of each weigh?
2. Given the recommended rate of fertilizer in lb/acre for a particular crop, find the amount of fertilizer needed in kilograms per hectare (kg/ha).
3. Using a 100 meter tape, measure a large area of the school campus and determine the number of square kilometers (km^2). Express the answer in hectares (ha). 1 km = 1000m and 1 ha = 10 000 m^2.
4. Taking the appropriate measurements, determine the storage capacity of a cylindrical farm storage bin in cubic meters (m^3). $V = \pi r^2 h$.
5. Determine the amounts of various ingredients and additives needed to prepare one metric ton (t) of a balanced ration for a particular class of livestock. Express each ingredient in kg/t.

6. The directions on a package of wettable powder pesticide calls for 10 ounces per gallon. Determine the recommendations in grams per liter (g/L). 1 ounce = 28 g and 1 gal = 3.785 L.

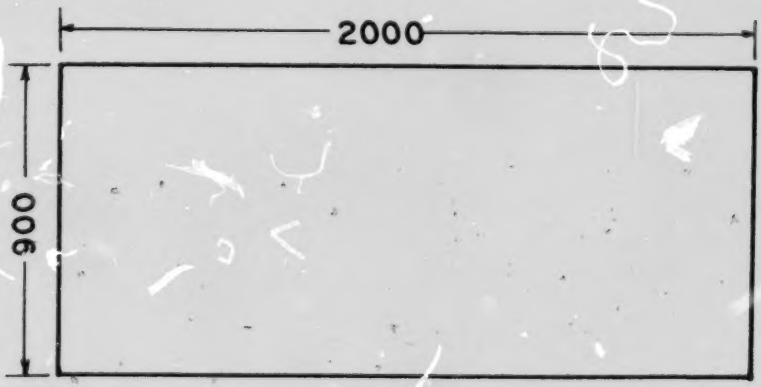
7. Figure 3-1 represents an area of land to be used for growing soybeans. Use the drawing and additional information provided to solve problems 7a through 7e.

   a. Since one hectare equals 10 000 m^2, find the number of hectares represented by the area.
   b. If soybeans are to be seeded at 44 kg/ha, how much seed will be needed to plant the crop?
   c. What is the seed cost per hectare if seed costs $0.27/kg?
   d. What it the total cost of seed for the land area?
   e. If the yield of the crop was 8500 kg, what was the yield per hectare in kilograms (kg/ha)? In metric tons (t)?

8. A feeder steer, weighing 180 kg, is fed dry feed for 270 days and then sold at a mass (weight) of 450 kg.

   a. What is the rate of grain in kg/day?
   b. If the steer is slaughtered and dresses out to 55% of live weight, what will the dressed mass (weight) be in kg?
   c. Given a sale price of $613.80, determine the price per kg received for the animal.
   d. If it took 675 kg of feed to raise the animal to slaughter weight, determine the amount of feed in kilograms required per kilogram of mass (weight) gain.

Figure 3-1
Agricultural Production Exercise



DIM. IN mm

Agricultural Resources

1. Using a soil sampler device, remove a core of soil from several locations. Estimate the topsoil (A horizon) depth in centimeters (cm) for each sample and record your estimate. Take the actual measurements and continue your practice until you can estimate with at least 80% accuracy.

2. Measure the velocity of a stream in meters per second (m/s).

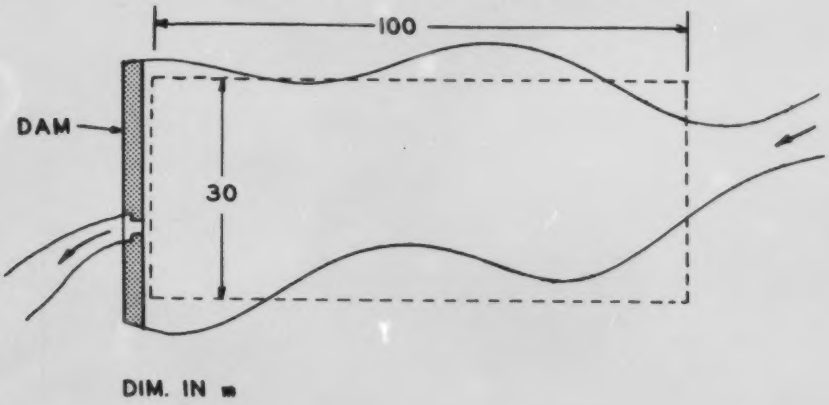
3. Locate an area of land in your community with a drainage problem. Following the recommendations of the local Soil Conservation unit, prepare a sketch for installation of a drainage system, along with a bill of materials needed. Express all measurements in metric values.

4. Determine the wind speed in miles per hour (mph) and find the equivalent kilometers per hour (km/h).

5. You are employed by the wildlife agency in your state, and you need to determine the volume of water in a small farm pond. The drawing in Figure 3-2 shows the shape of the pond. As you can see, the approximate dimensions can be measured as a rectangle. Do problems 5a through 5d.

   a. Determine the surface area of the pond in square meters (m^2). A = length × width.
   b. Assume that the pond is 4 meters deep at the deepest point. Compute the average depth for the pond using the formula: Ave. depth = deepest point × 0.4.
   c. Determine the cubic meters (m^3) of water in the pond. Volume (m^3) = surface area (m^2) × ave. depth (m).

Figure 3-2
Agricultural Resources Exercise



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6. Assume you are examining a field of idle land to determine the effects of slope upon erosion of the soil.

a. Determine the percentage of slope if the land falls 3.5 meters in 52 meters.

$$\% \text{ slope} = \frac{\text{meters of fall}}{\text{horizontal distance in meters}} \times 100$$

b. Find the percentage of soil loss.
Given: original topsoil depth = 38 cm
present topsoil depth = 21 cm

$$\% \text{ erosion} = \frac{\text{topsoil lost}}{\text{original topsoil}} \times 100$$

7. Determine the amount of gypsum needed to control sediment for a small pond in your community, if the recommended application rate is 5.5 kg gypsum per 26 m^3 of water.

Forestry

1. Estimate the diameter breast high (dbh) of several trees and record your estimate. Take the actual measurement using a metric rule and compare to see how close your estimates were.
2. Using a Celsius thermometer, record the temperature of the air in the wooded area on a warm, sunny day. Move out of the wooded area into an open area and record the air temperature. Is there a difference? Write one sentence to explain the influence of trees upon air temperature.
3. Read the recommendations for dilution of a herbicide such as 2,4,5-T. Determine the dilution rate in milliliters per liter (mL/L).
4. Provided 10 seedlings (one-year old) of a commercially important species of tree, measure the length of one-year seedlings for this species.
5. Secure leaves from several species of native trees. Estimate the length and width of each in centimeters. Then take the actual measurements using a metric rule and compare the results.
6. Given the dimensions of a standard cord of wood at 4 × 4 × 8 feet, determine the metric equivalent of a cord in cubic meters (m^3).

Agricultural Mechanics

1. Using a metric micrometer, measure the diameter of several parts of a disassembled motor and record your measurements.
2. Inspect the ignition system of a small gasoline engine. Measure the spark plug gap and the point gap using a customary inch feeler gauge. Measure both using a metric gauge (mm).
3. Given the horsepower of the engine of a tractor or other farm machine, calculate the power in kilowatts (kW). kW = hp/1.34.
4. An electric motor is rated at 8 amperes, 240 volts. Determine the motor rating to both watts and kilowatts. Watts = amperes × volts.
5. Determine the output of an irrigation system in liters per second.
6. Determine the amount of concrete, in cubic meters, required to construct

the floor of the agricultural mechanics shop at your school, if the concrete is 100 mm thick.

7. Given the capacity of the cooling system of a water-cooled engine, determine the capacity in liters. Determine the amount of antifreeze needed, in liters, to protect the engine to $-25\,^{\circ}C$.

8. You wish to calibrate a boom-type sprayer for broadcast application of pre-emerge liquid herbicide. Before the final adjustment of sprayer pressure and ground speed is made, you wish to make a test run using pure water in the tank.

a. Using the formula:

$$\text{hectares sprayed} = \frac{\text{width of boom} \times \text{length of run,}}{\text{square meters/hectare}}$$

find the area sprayed given the following:
width of boom = 4 meters
length of run = 400 meters
square meters/hectare = 10 000

b. Using the formula:

$$\text{liters/hectare} = \frac{\text{liters used}}{\text{hectares sprayed}}$$

, find the application rate if you used 40 liters of water.

c. Find the area that can be sprayed by a 500 liter tank using the formula:

$$\text{hectares/tankful} = \frac{\text{liters/tank}}{\text{liters used/hectare}}$$

Horticulture

1. Using a metric rule, measure the height, width and length of a nursery flat in centimeters. How much soil will the flat hold in cubic centimeters (cm^3)? In cubic decimeters (dm^3)?

2. Using a 100 meter tape, measure the length and width of a large expanse of lawn on the school campus. Determine the area of the lawn (length × width) in square meters (m^2). Compute the amount of fertilizer needed if it is to be fertilized at the rate of 1 kg of 10-10-10 per 9.3 m^2.

3. Given the ideal temperature for growth of various foliage plants in °F, determine the recommended temperature in °C by consulting a conversion chart.

4. The ideal tank pressure for spraying a particular insecticide is given at 276 kilopascals (kPa). Since your guage measures pressure in psi (pounds per square inch), determine the recommended pressure for your tank. 1 psi = 6.9 kPa.

5. Liquid fertilizer is to be applied as a foliar spray to young tomato seedlings. The dilution rate is given at 6 mL of dry concentrate to 2 L of water. How many teaspoonfuls are needed for your 5 gallon tank? 1 teaspoon = 5 mL and 1 gallon = 3.785 L.

6. Liquid pesticide is to be applied to bedding plants in the greenhouse. The label gives the dilution rate at 5 mL of concentrate per liter of water. How much concentrate is needed for a 9 liter spray tank?

Agricultural Products

1. Estimate the metric volume and mass of several containers of foods items available in local food stores. Using a metric rule and a kilogram scale, determine the actual measurements. How close were you?
2. As a buyer for a large meat processing facility, you purchase 40.75 metric tons (t) of live, choice beef. Determine the dressed mass (weight) percentage if the animals yield 21.5 metric tons of carcass mass (weight).
3. Determine the mass of butterfat in 900 kg of milk containing 5.2% butterfat.
4. Utilizing 140 employees, a dairy processing facility produces 722 million liters of milk and 266 million liters of ice cream each year. What is the average output per week of both milk and ice cream? What is the average output of each per employee per week?
5. As manager of a meats processing facility, you are to fill a custom order for 75 kg of hamburger in patties weighing 115 g each.
   a. How many patties will the 75 kg yield?
   b. If the patty mix is to contain 12% soybean meal, determine the amounts of both soybean meal and beef needed to prepare the 75 kg.

Agriculture Supplies

1. Determine the volume of space in your classroom in cubic meters. Now measure a standard bale of peat moss and determine the volume in cubic meters. If the classroom were a warehouse, how many bales of peat could be stored?
2. Read the directions on the label of several different pesticides. If the application rate is given in customary units, determine the metric equivalents and record your results.
3. A customer wishes to determine the amount of fertilizer needed to fertilize 100 ha of cropland if the recommended rate is 75 kg per acre.
4. A large truck used to deliver agricultural supplies has a bed measuring 5 m × 2.4 m × 1.5 m. If corn weighs 727 kg/m^3, what is the capacity of the truck in metric tons (t)?

REFERENCES AND RESOURCES

Agriculture teachers should begin now to acquire a library of metric information. A list of resource materials is presented in Chapter 8, some of which contains practical exercises for use with secondary level classes in vocational agriculture and agribusiness. The following references are recommended: 2, 4, 6, 15, 21, 26, 28-36, 42, 61, 64, 65, 72, 76, 82, 84, 86, and 89. (See Chapter 8.)

CHAPTER 4

Metrics in Business and Distributive Education

Ralph E. Mason and Peggy J. Dotson

INTRODUCTION

The pace of metric change in commerce, industry and consumer products affects business and distributive education programs at a commensurate rate. For example, because marketing involves transferring goods or services from the producer to the consumer, the move to metric usage in marketing and distribution will proceed only as rapidly as metric changes are made in the product and service areas. Consumers depend upon sales people to inform them of quantities needed, as well as to explain the qualities of a product. Packaging often sells a product, and in many instances packages have already been changed to metric sizing. Students will be expected to "sell" the metric tools and equipment used throughout industry. These and other factors will gradually lead to curriculum change in educational programming.

Young people and adults who are preparing for or who are already employed in business occupations can become familiar with metric measures through frequent and meaningful use of SI units applied to business situations. For example, changes in paper sizes will have an influence on typing and other office practices. Metric terminology will have an impact on shorthand. Metric sizes will add a dimension to clerical operations associated with inventory, cashiering and pricing. In business mathematics, emphasis may be placed on decimal operations and on understanding relationships among metric units. In consumer education, comprehending metric-sized units of merchandise and their customary equivalents may assume importance.

Business and distributive education personnel can gain information and direction on strategies for metric change in their programs by studying this chapter and its appropriate references. Other chapters in this book, such as the one on home economics, provide additional related information.

STANDARDS

Many metric standards relate to the business/distibutive area: paper sizes, limited character sets, typewriter keyboards, shorthand symbols and editorial practices are among the most important and obvious. However, other standards such as those referring to clothing and metric package sizes, and the range of metric tools also warrant examination for their applications to product distribution. Some examples are shown in Figures 4-1 and 4-2. Others may be found elsewhere in this book, particularly in the chapter on home economics.

INSTRUCTIONAL STRATEGIES

There are several key issues to be considered as business/distributive educators begin to plan for metric change. Some are measurement sensitive, while others deal with practices and standards. The most important of these issues are:

1. Paper sizes

2. Typewriter keyboards and carriages
3. Shorthand symbols for metric measurements
4. Limited character sets
5. Editorial practices
6. Merchandise packaging and pricing
7. Computer programming to accommodate metric units.

Each of these factors is treated in this chapter; each must be addressed in order to comprehend fully the relationships to program change. The teacher must study them before appropriate learning activities can be developed.

Perhaps the typewriting classroom will serve as an illustration of how one might teach metrics. Leave the word *inch* out of the typing classroom. Instead of talking about margins or line lengths in terms of inches, typists must think in terms of lines and spaces. For example, the teacher should say, "Type the

Figure 4-1
Gregg Metric Shorthand Guide

meter
kilometer
centimeter
millimeter
kilogram
liter

Figure 4-2
Series A and Series C
Metric Paper Sizes

A-Series Paper		C-Series Envelopes	
Size	mm	Size	mm
A0	841 × 1189	C0	917 × 1297
A1	594 × 841	C1	648 × 917
A2	420 × 594	C2	458 × 648
A3	297 × 420	C3	324 × 458
A4	210 × 297	C4	229 × 324
A5	148 × 210	C5	162 × 229
A6	105 × 148	C6	114 × 162
		DL	110 × 220
A7	74 × 105	C7	81 × 114
A8	52 × 74	C8	57 × 81
A9	37 × 52		
A10	26 × 37		

The 210 × 280 mm A-series size will also be used.

date on line 15 and the inside address five lines down from the date . . . begin the first page of a manuscript on line 13."

The change to metrics provides a new opportunity to restructure measurement concepts clearly and correctly, toward a rethinking of how students learn to measure. Estimation rather than conversion will help students to understand metrics and develop a feel for these new sizes.

Ideas for concept development and measurement activities are found in this chapter and in the resources listed in Chapter 8. The more often the student "thinks" and "uses" metrics, the greater the understanding will be. To teach metrics, use those proven techniques that already are effective in teaching. How did you learn what a quart of milk looked like? Did you have to know 32°F and 212°F before you could read a thermometer? How did you learn to measure inches and feet? Remember, there are only a few metric units one must learn. Select one unit and use it to measure and estimate in as many situations as is practical; this will be the beginning of metric thinking. Help students to become proficient in the multiples needed to become successful on the job and to maintain the pace of training to match the metric implementation needs of business.

MACHINES AND EQUIPMENT

Perhaps the single most important change in this topical area is the keyboard modification required to give typewriters a metric capability. A number of minor revisions will have to be made if metric symbols are to be typed correctly:

1. The mu symbol (μ) refers to the "micro" prefix and must be added.
2. The degree symbol (°) must be added, as it applies to temperature and angle references.
3. The superscripts (^{2}) and (^{3}) are required for typing squared and cubed units and to express powers of 10.
4. The Greek capital omega (Ω) would be useful as would the product dot (·).
5. Bracket symbols ([ ]) would be helpful for dual dimensioning and for mathematical expressions.

Room for these additions could be provided by eliminating the ½, ¼, @ and # key. Keyboard modification plans are being studied, and appropriate recommendations have been made. The teacher should check with suppliers regarding the availability of replacement keys and typing ball elements. Other tool and equipment changes eventually will be necessary as product standards change. Examples include filing cabinets, weighing scales, product display cases and paper punches.

Some computer print-out units and word processing systems do not have lower case characters. Rather than restrict these systems for metric application, a "limited character set" has been developed. Users of the copy produced by these systems will need to be acquainted with this mechanical limitation. Refer to Chapter 8, item (70) for further details.

Considerable study should be given to a replacement schedule for equipment and machines. Service should be performed as needed, and when an item is due to be replaced, do so with an appropriate metric model.

SAMPLE TEACHING ACTIVITIES

The activities included in this section illustrate the range of experiences that can help students learn to use metrics in business and distribution programs.

1. *Purchase Order Problem.* A common clerical task is to prepare purchase orders for office supplies. Study the table below and enter the metric *replacement* sizes for the common items shown. For example, the replacement size for a gallon of duplicator fluid is 4 liters. Type a purchase order for the items using metric units. Consult a current catalog for prices.

CUSTOMARY	METRIC
1 gallon of duplicator fluid	4 liters
6 rolls ½" × 60 yards masking tape	
450' of 10 ply twine	
6 fl. oz. of correction fluid	
½ lb. of rubber bands	
1 pt. of hand cleaner	

2. *Proofreading and Typing Problem.* Proof the following advertisement which contains spelling, symbol, notation, and substitution errors. Type a final printable copy.

FOR SALE

Lovely old colonial home located on wooded tenHectare lot in Winchell School area, just 10KM from the nearest shoping center. The house has 225 sq. m. of floor space, a large 400 cms × 730 cm living room; formal 335 cm × 430 centiliter dining room; three bedrooms; two full baths; and seperate two car garage. For information call Metric Realty at 349-2862.

3. *Limited Character Set Problem.* Complete the table below by adding the missing unit representations, as per the example for meter.

UNIT	SYMBOL	REPRESENTATION
meter	m	M
kilogram	kg	
second	s	
ampere	A	
kelvin	K	
mole	mol	
candela		

4. *Miscellaneous Problems.*

a. Examine a display of grocery items and determine the accuracy of the metric symbols (e.g., GMS instead of g).

b. Have each student prepare a chart of his or her metric clothing sizes, such as shirts, slacks, gloves and dresses.

c. Have students visit local hardware stores and prepare a list of common metric items found there, such as drills, wrenches, taps and dies and rules.

REFERENCES AND RESOURCES

Recent professional publications in business and distributive education have included articles about teaching the metric system in various courses and in training plans in cooperative education. Several such resources are listed in Chapter 8. In addition, the National Business Education Association has published a practical guide to metric measurement in business education (Reference 34) and readers are encouraged to secure copies of it. Valuable references for business and distributive education are: 2, 4, 6, 11, 16, 17, 28, 31, 33-36, 39, 41, 42, 62, 68, 70-72, 84 and 86. (See Chapter 8.)

CHAPTER 5

Metrics in Health Occupations Education

Ina E. Conley

INTRODUCTION

A substantial basis for metric measurement in the health care field has existed for many years. Typically, the hospital and pharmaceutical company formularies are in the metric format with little reference to inch-pound units except in equivalent charts. Medical research generally is metric, and most drugs are manufactured in SI units and standards. Eyeglasses are prescribed and the lenses ground to metric specifications. Citizens are familiar with metric notations on the medicines they purchase and use. Training for medical technicians is exclusively metric, and programs for medical aides are gradually changing. Truly, the medical industry is heavily involved in metrication.

Medical and health education curricula must be modified to include training in the proper use of metric units as soon as is practical. Benefits do accrue. Many training programs for nurses have indicated a time-saving of nearly 10 percent because of the simplicity of the metric system. This has allowed for a broadening of the curriculum without requiring additional time. The pace at which the metric system is written into existing health curricula is influenced by a number of factors:

1. Occupational areas that require licensing (such as nursing) will change as the licensing agencies include metrics in their registration examinations.
2. Medical organizations, such as the American Dental Association, may recommend metric modifications in health occupational education in order to accommodate changing requirements in the dental profession.
3. State boards of medicine and/or health occupations may mandate curriculum changes in response to new metric developments and needs.
4. Certain health occupations, such as licensed practical nursing, are more metric measurement sensitive than others (for example, medical records clerk) and would naturally require more immediate and comprehensive curriculum changes.
5. Aggressive, innovative instructors and administrators can also affect metric curriculum change by applying information gained from conferences, reading and self-study.

The administrators of health occupation programs ultimately are responsible for curriculum change. It is imperative that they remain alert for changes, such as those emanating from the above sources, and facilitate changes promptly and according to an established plan.

The scope of this chapter is limited to those health occupations programs that are generally unlicensed and considered to be of entry level and which characteristically serve high school students or adults attending area skills or vocational/technical education centers. The purpose of this chapter is to identify the important elements of metric conversion in the health occupations and present information on implementation. The intended result is a coordinated conversion program operating efficiently and at least cost.

INSTRUCTIONAL STRATEGIES

Instructional strategies used in the changeover to metrics should refer specifically to job-related tasks that currently involve the use of inch-pound measures. To illustrate this, some examples of required tasks for nurse's aides follow.

1. When measuring a patient's temperature, the student should know that normal temperature (oral) is 98.6°F or 37°C. The student should be able to follow procedures for taking temperature and be able to read and record both Celsius and Fahrenheit thermometer readings accurately.
2. When giving a patient a complete bed bath, the student should use a bath thermometer to insure that the bath water is at 115°F or 46°C.
3. When measuring fluid intake and output, the student should use containers that may be calibrated in cubic centimeters or in both cubic centimeters and ounces. The milliliter should replace the cubic centimeter unit.
4. When weighing a patient, the student should use a scale that may give weight (mass) in pounds and ounces or in kilograms.

The approach should focus on competent task performance providing opportunities for students to "think metric" and apply SI to tasks required on the job. As far as possible, the metric system should be used in all procedures now using inch-pound measures. Students will need to be able to use both measurement systems until all hospitals and clinical sites are totally metric.

In this changeover process, strategies will be developed to a great extent by the teachers themselves. For example, methods can evolve out of a written plan of action for conversion to metrics in health occupations. All appropriate teaching staff should participate in this process and a plan of action should be developed, discussed and agreed upon to include a table of completion dates. A typical plan of action might read as follows.

1. Instructors should make a list of each task within the curriculum that calls for inch-pound measurements and the appropriate measuring equipment in use. Prices of similar metric equipment should be noted if available.
2. Textbooks and manuals presently in use should be reviewed for proper metric units, procedures, and techniques. If techniques are well presented, this information should be shared with colleagues. Use an editorial guide, such as Reference 4 (See Chapter 8), to check the accuracy of metric data.
3. Review copies of new or revised book editions should be requested from publishers to study for metric accuracy. Now available are revised editions of books that display excellent diagrams, tables and clearly stated procedures showing changes from inch-pound units to metric. This type of book can be read and followed by most students and can serve as a basic guide to metric change.
4. Each teacher should take the responsibility for becoming proficient in teaching metrics as called for in the curriculum. This might be accomplished through local inservice education programs and independent study. Most health professionals already have some background in the metric system.
5. Teachers should develop lists of ways to present metric information, identify resources, and devise student projects. These should be shared with the group. This plan of action and its implementation should be interrelated with the overall metric conversion plan for an institution.

Instructional strategies for metric change should encourage student participation. Examples of this follow.

1. Reviewing for metric information might be carried out in the classroom with students assisting in the process. Students could be divided into several groups, each group reviewing a different section of the book. After all sections have been reviewed, students may wish to pencil in metric measurements where only inch-pound measures are given.

2. Students might be encouraged to "think metric" by planning youth club activities that focus on metrics. Students themselves need to appreciate the benefits of metric conversion. Willing and able persons who are proficient in the use of metrics might be called upon as speakers. For example, medical technologists and pharmacists use the metric system extensively in their professional activities.

3. Students may wish to put on a metric display emphasizing how metrics will simplify measurement processes.

4. Students generally participate in health fairs that are sponsored by some centers. Such events may be used to promote and explain conversion to the metric system. At health fairs, students can provide services such as taking blood pressures and providing information about keeping healthy. Health agencies cooperate by putting up displays and providing consultants and information. Students might develop captions that focus on metrics, for example:
   a. Watch your weight in kilograms.
   b. Your temperature is only 37 °C.
   c. Count your joules, not calories.
   d. How many mL of milk to you drink each day?
   e. How metrically tall are you?

5. Students might participate in planning projects to display for open house programs. Advantages of the metric system could be demonstrated at these events by posters, diagrams, instruments and equipment used in metric measurement and information hand-outs.

6. The teacher might involve students in making visuals for use in metric instruction. For example, have the students use metric rules in making flash cards to teach Celsius temperature reading and have students make large posters comparing Celsius and Fahrenheit thermometers. Through this type of project, students often come up with good, original ideas for other visuals.

Teaching strategies having the greatest impact are those used in the laboratory during and following supervised clinical experience at health care institutions. Preparation includes skillful demonstrations by the teacher in the clinical laboratory, followed by assistance and constructive supervision to help each student gain necessary competency in task performance. Since students must be able to fit into an organized working pattern, get along with staff and perform required tasks competently, all instruction must be geared toward actual performance on the job.

The teacher and students need to know what tasks will be required and the types of equipment, tools and machines they will be using. The astute teacher establishes lines of communication to become informed about changes taking place in local health care institutions. Knowledge of the status of metric conversion is important so that students may be prepared accordingly.

STANDARDS

The standards for medicine and health range from engineering norms for medical devices to recommended values for height, weight, temperature and blood pressure measures. Standards that require immediate attention must be identified. Appropriate liaison activities must be established and maintained with standards agencies. Approved standards need to be woven into the medical education programs to reflect and effect metric change. A sampling of standards is presented here and others can be found in the references in Chapter 8. It is important to note that many medical standards remain to be written. Medical education must remain alert for their appearance, and to apply these new standards to the proper technical area. See Figures 5-1 and 5-2.

TOOLS, INSTRUMENTS AND EQUIPMENT

Medical equipment needs for educational facilities can be costly as measurement devices begin to feature SI metric units. For example, respiratory physiology pressure readings will be in kilopascals, necessitating the purchase of new equipment. However, such purchases need not be made all at once; new equipment should be phased in over a period of years. It is important to stay informed regarding the availability of this new equipment, so that proper replacement scheduling and budgeting can take place.

When planning for equipment replacement, bear in mind the following factors:

1. Many laboratory items are already SI metric.
2. Some devices and instruments feature obsolete metric units, such as volume measures graduated in cubic centimeter units instead of milliliters (mL). These must be replaced.
3. As metric replacements are phased in, the inch-pound devices must be discarded to prevent confusion and measurement errors. Avoid reliance on conversion tables, except to establish metric relationships and a "feel" for new units.
4. Teaching devices used in the classroom can be temporarily modified to include metric units, pending the availability of proper metric devices. For example, a decal can be applied to the face of a scale to change the graduations from pounds to kilograms.
5. New equipment purchases should be made as dictated by prior curriculum and program changes. Convert at the proper time.

The general and specialized medical equipment items that must be replaced as metric changes occur are thermometers, weight (mass) and height scales, graduates and other laboratory volume measures, syringes, balances and pressure and temperature gauges. Other specific items related to occupational areas are mentioned in the following:

Dental Assisting. Typical of specialized tools already calibrated in metrics are the periodontal probe and the Boley gauge. Changes needed include temperature and pressure gauges on casting ovens, sterilization ovens, autoclaves, dry-heat sterilizers, thermometers incorporated in mixing slabs, floating style thermometers for film developing and graduates for measuring solutions.

Dental Laboratory Technology. Although this field is predominantly metric, changes needed include temperature and pressure gauges on casting ovens and other equipment. Most measurements are in metric units, but some procedures use both metric and inch-pound measures.

Figure 5-1
Blood Pressure

The kilopascal (kPa) may be used instead of the millimeter of mercury (mmHg).

mm Hg →	kPa 0	1	2	3	4	5	6	7	8	9
0	–	0.1	0.3	0.4	0.5	0.7	0.8	0.9	1.1	1.2
10	1.3	1.5	1.6	1.7	1.9	2.0	2.1	2.3	2.4	2.5
20	2.7	2.8	2.9	3.1	3.2	3.3	3.5	3.6	3.7	3.9
30	4.0	4.1	4.3	4.4	4.5	4.7	4.8	4.9	5.1	5.2
40	5.3	5.5	5.6	5.7	5.9	6.0	6.1	6.3	6.4	6.5
50	6.7	6.8	6.9	7.1	7.2	7.3	7.5	7.6	7.7	7.9
60	8.0	8.1	8.3	8.4	8.5	8.7	8.8	8.9	9.1	9.2
70	9.3	9.5	9.6	9.7	9.9	10.0	10.1	10.3	10.4	10.5
80	10.7	10.8	10.9	11.1	11.2	11.3	11.5	11.6	11.7	11.9
90	12.0	12.1	12.3	12.4	12.5	12.7	12.8	12.9	13.1	13.2
100	13.3	13.5	13.6	13.7	13.9	14.0	14.1	14.3	14.4	14.5
110	14.7	14.8	14.9	15.1	15.2	15.3	15.5	15.6	15.7	15.9
120	16.0	16.1	16.3	16.4	16.5	16.7	16.8	16.9	17.1	17.2
130	17.3	17.5	17.6	17.7	17.9	18.0	18.1	18.3	18.4	18.5
140	18.7	18.8	18.9	19.1	19.2	19.3	19.5	19.6	19.7	19.9
150	20.0	20.1	20.3	20.4	20.5	20.7	20.8	20.9	21.1	21.2
160	21.3	21.5	21.6	21.7	21.9	22.0	22.1	22.3	22.4	22.5
170	22.7	22.8	22.9	23.1	23.2	23.3	23.5	23.6	23.7	23.9
180	24.0	24.1	24.3	24.4	24.5	24.7	24.8	24.9	25.1	25.2
190	25.3	25.5	25.6	25.7	25.9	26.0	26.1	26.3	26.4	26.5
200	26.7	26.8	26.9	27.1	27.2	27.3	27.5	27.6	27.7	27.9
210	28.0	28.1	28.3	28.4	28.5	28.7	28.8	28.9	29.1	29.2
220	29.3	29.5	29.6	29.7	29.9	30.0	30.1	30.3	30.4	30.5
230	30.7	30.8	30.9	31.1	31.2	31.3	31.5	31.6	31.7	31.9
240	32.0	32.1	32.3	32.4	32.5	32.7	32.8	32.9	33.1	33.2
250	33.3	33.5	33.6	33.7	33.9	34.0	34.1	34.3	34.4	34.5
260	34.7	34.8	34.9	35.1	35.2	35.3	35.5	35.6	35.7	35.9
270	36.0	36.1	36.3	36.4	36.5	36.7	36.8	36.9	37.1	37.2
280	37.3	37.5	37.6	37.7	37.9	38.0	38.1	38.3	38.4	38.5
290	38.7	38.8	38.9	39.1	39.2	39.3	39.5	39.6	39.7	39.9
300	40.0	40.1	40.3	40.4	40.5	40.7	40.8	40.9	41.1	41.2
310	41.3	41.5	41.6	41.7	41.9	42.0	42.1	42.3	42.4	42.5
320	42.7	42.8	42.9	43.1	43.2	43.3	43.5	43.6	43.7	43.9
330	44.0	44.1	44.3	44.4	44.5	44.7	44.8	44.9	45.1	45.2

122 mmHg = 16.3 kPa
(mmHg) x 0.1333 = (kPa)
(kPa) x 7.501 = (mmHg)

Figure 5-2
Taking Body Temperature

°F ▶ °C

	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9
95	35.0	35.1	35.1	35.2	35.2	35.3	35.3	35.4	35.4	35.5
96	35.6	35.6	35.7	35.7	35.8	35.8	35.9	35.9	36.0	36.1
97	36.1	36.2	36.2	36.3	36.3	36.4	36.4	36.5	36.6	36.6
98	36.7	36.7	36.8	36.8	36.9	36.9	37.0	37.1	37.1	37.2
99	37.2	37.3	37.3	37.4	37.4	37.5	37.6	37.6	37.7	37.7
100	37.8	37.8	37.9	37.9	38.0	38.1	38.1	38.2	38.2	38.3
101	38.3	38.4	38.4	38.5	38.6	38.6	38.7	38.7	38.8	38.8
102	38.9	38.9	39.0	39.1	39.1	39.2	39.2	39.3	39.3	39.4
103	39.4	39.5	39.6	39.6	39.7	39.7	39.8	39.8	39.9	39.9
104	40.0	40.1	40.1	40.2	40.2	40.3	40.3	40.4	40.4	40.5
105	40.6	40.6	40.7	40.7	40.8	40.8	40.9	40.9	41.0	41.1
106	41.1	41.2	41.2	41.3	41.3	41.4	41.4	41.5	41.6	41.6
107	41.7	41.7	41.8	41.8	41.9	41.9	42.0	42.1	42.1	42.2

98.6 °F = 37 °C
(°F − 32) x 0.5556 = (°C)
(°C) x 1.8 + 32 = (°F)

Medical Assisting. Most equipment changes needed are the same as those listed under *Nursing and Nurse's Assisting.* Additional changes would reflect equipment and supplies used in business education, such as typewriters with metric symbols.

Medical Laboratory Assisting. The metric system is already in use in this field.

Nursing and Nurse's Assisting. Oral and rectal body temperature thermometers and room thermometers should read in degrees Celsius. Syringes should be calibrated in milliliters, and length and gauge of hypodermic needles will eventually be stated in metric units. Graduates and other containers for measuring fluids should be calibrated in milliliters. Equipment such as autoclaves and other equipment using heat and pressure gauges will need changes. Specialized, costly equipment needing metric updating is usually available for student use at supervised clinical experience sites.

SAMPLE TEACHING ACTIVITIES

Metrics can be introduced effectively through hands-on experiences with metric measuring equipment and devices used in the health occupations. Some examples follow.

Dental Assisting. Use the Boley gauge to measure an extracted tooth. Include all aspects: length of crown, length of root, mesio-distal diameter of crown, mesio-distal diameter of crown at cervix, labio-lingual diameter of crown, labio-lingual diameter of crown at cervix and curvature of cemento-

enamel junction on mesial. Use containers calibrated in milliliters to measure and prepare a 10 percent solution of sodium chloride.

Dental Laboratory Technology. Working in pairs, have the students take and record the following measurements in metrics: hand span; palm; wrist to finger tips; wrist to elbow; elbow to shoulder; shoulder width; head circumference; calf circumference; height; weight; oral temperature; waist; hips and chest. Perform the activities shown in Figure 5-3.

Figure 5-3
Metric Devices Practice

Name five metric measuring devices used in a hospital or laboratory. Give purpose of device, metric symbol used and normal recording.

Name of metric measuring device	Purpose of device	Metric symbol used	Normal recording (if appropriate)
1.			
2.			
3.			
4.			
5.			

Nursing and Nurse's Assisting. Refer to the unit in your textbook which covers patient intake and output. Use graduates calibrated in milliliters and carry out the required procedures for measuring intake and output, including recording the metric units correctly. Set up metric stations in the classroom or laboratory for measuring weight (mass), height, oral body temperature, and use of the bath thermometer. Have the students move from station to station making measurements and recording them in metric units only.

Medical Assisting. Use the metric station format as described under *Nursing and Nurse's Assisting.* Use preparation of saline solution activity as described under *Dental Assisting.* Take the metric quiz, Figure 5-4.

REFERENCES AND RESOURCES

Administrative, instructional, and support personnel will find these references helpful as they proceed with the planning for metric change: 1, 3, 6, 11, 17, 22, 28, 37, 38, 39, 40, 42, 82, and 89. (See Chapter 8.)

Figure 5-4
Metric Health Quiz

Circle the correct answer.

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1. Average height for a boy 17 years of age is:
   a. 96 cm
   b. 128 cm
   c. 143 cm
   d. 177 cm
2. Average mass (weight) for a boy 17 years of age is:
   a. 13 kg
   b. 26 kg
   c. 39 kg
   d. 64 kg
3. Normal (oral) body temperature is:
   a. 37 °C
   b. 38 °C
   c. 39 °C
   d. 40 °C
4. A thermometer reading of 40 °C indicates the patient has a:
   a. normal temperature
   b. low fever
   c. mild fever
   d. high fever
5. The temperature of a patient's room should be:
   a. 10 °C
   b. 20 °C
   c. 30 °C
   d. 40 °C
6. Graduates used to measure fluids should be calibrated in:
   a. kilograms
   b. centimeters
   c. milliliters
   d. kilopascals

CHAPTER 6

Metrics in Home Economics Education

Judy R. Oppert

INTRODUCTION

The change to metrics affects every consumer in the marketplace. Many people are purchasing gasoline, soft drinks and alcoholic beverages in metric units. Labels on most packaged goods contain both metric and customary inch-pound measurement units. Most automobiles indicate speeds in metrics and are designed and manufactured to metric specifications. Sewing patterns feature metric units and appropriate clothing construction tools are available. Metric recipes are being published and most measuring cups now sold display metric as well as customary units.

Home economics educators need to prepare themselves, their programs and their students to make intelligent decisions as the change to metric measurement continues. The information in this chapter will help the reader begin this preparation. The subject matter areas of foods, nutrition, clothing, textiles and home furnishings are featured because measurement is an integral part of these subjects. In addition, measurement units are often included in areas such as consumer education and child development.

INSTRUCTIONAL STRATEGIES

The easiest way to incorporate metrics into a subject area is to use metric units and measuring tools exclusively. This eliminates the need to convert between metric and inch-pound measurement units, and saves time and frustration. Conversion is proper only insofar as it helps the learner understand the size relationships between units.

Using metric units also eliminates most fractions. It is much easier to help a student double or halve 200 milliliters than 2/3 cup. Changing seam allowances to 1.5 centimeters allows students to easily calculate increases or decreases without trying to manipulate the customary 5/8-inch fraction.

Changing all of the present measurement activities to metric requires that the teacher learn the metric system. It has been estimated that the important elements of the system can be learned in a few hours, as most teachers will use only a limited number of the units. The following outline indicates the units to be used:

1. Clothing, Textiles
   a. Sizes—centimeter
   b. Sewing—meter, centimeter, millimeter
2. Home Furnishings
   a. House and Lot—hectare, square meter, meter
   b. Appliances—square meter, cubic meter, liter, milliliter, centimeter, degree Celsius
   c. Interior Decoration—square meter, meter, centimeter, liter
   d. Lawn and Garden—hectare, square meter, liter, meter, centimeter, gram

3. Food, Nutrition
   a. Food Preparation—liter, milliliter, degree Celsius, kilogram, gram, kilopascal, centimeter
   b. Nutrition—kilojoule, kilogram, gram, milligram, milliliter, meter.

Metric units are most easily learned by using them, that is, through "hands-on" activities. The teacher can read about the unit and memorize its symbol, but it doesn't become meaningful until she or he has a feeling for the size of the unit. Relating the unit to an item in the environment is very helpful. For instance, a centimeter is approximately the width of a fingernail, and a meter is about the height of a doorknob from the floor. Similarly, students need to actively use metric units and relate them to things with which they are familiar.

Using metric units without converting to inch-pound units makes it easier to think in terms of metric sizes. The phrase "think-metric" is often used to express this concept. It is easy to do and a positive attitude will, in turn, affect the students. There are many advantages in using metrics, such as the elimination of many fractions, which can be stressed to students.

STANDARDS

It has been estimated that 80 percent of our packaged food products have labels containing both metric and inch-pound measurements units. Soft drinks are being sold in liter bottles, but most other food products have not gone through the "hard conversion" phase. Therefore, most foods are still purchased in inch-pound units. As metrication proceeds, package sizes will be standardized, and it will be easier to do comparison shopping. For example, a consumer might be able to compare prices of 50, 100, 150 and 200 milliliters of toothpaste.

At present, nutritional values on labels are given in metric units, but serving sizes are given in customary units. Eventually the serving sizes will probably be changed to metric units.

Metric recipes are available and others are being tested and published. When choosing metric recipes, look for those that contain volume units (milliliters and liters) where spoons and cups have been used. As explained in Chapter 1, dekaliters, deciliters and centiliters should not appear. Measurements should be "rounded," such as 1, 2, 5, 15, 25, 50, 125 and 250 milliliters. When other numbers appear (such as 236), it indicates that customary recipes have been converted too precisely. It is both difficult and unnecessary to measure these quantities so precisely. Grams and kilograms will be used to measure meats and other items, just as ounces and pounds are now used to measure certain ingredients in our recipes.

Kilojoules will replace kilocalories. Joules will be used to measure all forms of energy, not just food energy. This will make energy measurement much simpler, because students will have a much better understanding of the joule because they will have used it to measure other forms of energy.

Metric clothing sizes generally are based on centimeter body measurements. It seems logical that garment manufacturers and pattern makers will standardize sizes so that one size will be the same worldwide. Also, the number in the size would refer to a specific body measurement. Sizes like, "six months, 2 X, and 12" will become a thing of the past, and 60 would mean a garment that would fit a specific part of the body measuring 60 centimeters. Larger numbers

may be at first uncomfortable, but one won't have to memorize unrelated numbers for glove sizes, shoe sizes, hat sizes, ring sizes and blouse sizes.

Fabrics will be measured in meters, and zippers in centimeters. Figures 6-1 and 6-2 show typical changes. Consumers can refer to the pattern envelope, just as they do now, in order to determine how much fabric to buy and what size notions are needed.

Figure 6-1
Fabric Width Replacement Sizes

Inches	Centimeters
35/36	90
44/45	115
48	122
54/56	140
58/60	150
72	180

Figure 6-2
Zipper Length Replacement Sizes

Inches	Centimeters
5	12
7	18
9	23
10	25
12	30
14	35
16	40
18	45
20	50
30	75

In home furnishings, wall and floor coverings will be measured in square meters, and liquids (such as paint) in liters. Graph paper is now available in centimeter scale and house plans drawn to a metric scale will become available.

Changes will occur in the actual sizes of items when the size-designation numbers are rounded. For instance, the present standard mattress sizes would be clumsy when expressed in centimeter equivalents. Because people have tended to become taller, the centimeter numbers will be "rounded" up to larger numbers. Thus, mattresses (and the related linens) will actually be a little bigger when they are converted to metric.

TOOLS, EQUIPMENT, AND MACHINES

Metric items can be purchased, made or borrowed. Ultimately every item containing inch-pound measurement units in the department will be replaced. At present, in some locales it may be difficult to find some items with metric units, for instance, ranges marked in degrees Celsius. It is unnecessarily expensive to replace every item at the same time. Costs can be reduced by replacing items as they wear out and a replacement schedule will help spread the costs over several years.

The following list includes items found in many home economics departments that currently contain inch-pound units and should be replaced. The reader's department may not have all of this equipment, nor will it all be needed for metrication to begin.

Food and Nutrition

1. Volume measures (1, 2, 5, 15, 25, 50, 125, 250 and 500 milliliters, one liter).
2. Cooking and baking utensils (Marked in volume, such as one liter.)
3. Thermometers and temperature gauges. (A temperature conversion chart is shown in Figure 6-3.)
4. Scales
5. Food preservation equipment (The design and/or size of pressure canners may change in order to hold liter jars.)
6. Built-in appliances (When these appliances are replaced, new sizes may mandate carpentry or cabinet work.)
7. Temperature charts
8. Nutrition charts

Figure 6-3
Temperature Conversion Chart

Degrees Celsius	Degrees Fahrenheit
150	300
160	325
180	350
190	375
200	400
220	425

Note: When using glass utensils in the oven, reduce the temperature by 10°C.

Clothing and Textiles

1. Rulers
2. Tape measures
3. Seam guide
4. Sleeve guide
5. Hem markers and guides

6. Cutting boards
7. Buttonhole templates
8. Temperature gauges on irons and laundry equipment
9. Sewing machine stitch regulators (European and Japanese machines feature stitch regulators based on millimeters.)
10. Seam allowance guides (New guides can be constructed for American machines and taped over present guides.)

Home Furnishings

1. Meter sticks
2. Tape measures
3. Rulers
4. Templates
5. Scales

Are there additional items in the department that feature inch-pound measurement units? Don't forget to include them on the replacement schedule.

When making purchases, look for measurement tools that contain only metric units with the degree of accuracy required. For example, a tape measure with metric units on one side and customary units on the other can result in much confusion and many errors. It also allows students to continue using the customary system and convert between measurement systems, unless properly advised. The students who use only metric units will learn the system much faster and with less confusion.

Some educational activities require greater precision than others. For instance, room arrangements drawn to scale will be easier with rules containing millimeter units, but millimeter markings will not be needed on meter sticks used to measure room dimensions. Choose measurement tools with units appropriate for the tasks.

For low budget metric projects, necessary tools can be borrowed or made.

1. *Meter sticks* can be cut from scrap pieces of plywood or wood by the lumber yard or industrial arts department. Students can mark meter sticks into centimeter division using a purchased meter stick or tape measure as a guide. Also, some businesses give away meter sticks.

2. *Tape measures* can be made from strips of oil cloth. Students can cut strips (a small check pattern provides cutting lines) and mark units on the reverse side.

3. *Rulers* can be cut from poster board or similar materials.

4. *Volume measures* can be made from half-gallon milk cartons. Pour a liter of water (science departments generally have liter beakers) into the carton, and mark the height of the water. Then cut the carton off *above* the water line. Cans can also be filled with known quantities of water and marked to make metric measures. A tablespoon measure is approximately 15 milliliters and a teaspoon measure is approximately five milliliters.

5. *Thermometers* can be converted by making new scales. (The centigrade scale is identical with the Celsius scale, so no conversion is necessary for centigrade thermometers.) Locate the freezing and boiling points and mark them 0 and 100 respectively; then divide the space in between into 100 equal portions or degrees. Fasten the new scale over the old one.

When using measurement scales that have gone through a reproduction process (such as a ruler cut from a book), it is best to check the accuracy of the tool. The scale may have been distorted during the reproduction process. Students can become very frustrated when trying to draw a floor plan with centimeter rulers that do not agree with centimeter graph paper. Educators may wish to check the accuracy of all new measurement tools.

SAMPLE TEACHING ACTIVITIES

The following activities are but a few suggestions that can be used to help teach students to "think metric." This list may suggest more ideas that will be particularly appropriate in the reader's teaching situation.

Food and Nutrition

1. Review the following recipe with students. How does it differ from customary recipes? What information is needed before this recipe can be used? What equipment is needed? (If it is not available, can it be constructed, borrowed or purchased?)

PUMPKIN BREAD

500 mL pumpkin	5 mL salt
500 mL sugar	5 mL cinnamon
150 mL salad oil	5 mL nutmeg
100 mL water	2 ml cloves
3 eggs	125 mL raisins
600 mL flour	125 mL chopped nuts
10 mL baking soda	

Heat oven to 160°C. Grease and flour bottom of two loaf pans. In large bowl, blend first five ingredients. Beat one minute at medium speed with electric mixer. Sift flour, soda, salt, cinnamon, nutmeg and cloves together. Add to pumpkin mixture and mix. Beat one minute at medium speed. Stir in raisins and nuts. Pour into pans and bake 50 to 60 minutes until toothpick inserted in center comes out clean. Cool in pans five minutes; remove and cool completely.

Make pumpkin bread and compare the procedure with making a similar recipe in customary units.

2. Determine the metric volume or capacity of items in the department such as pitchers, dishes, pans and appliances, and label them.

3. Fill a number of different shaped containers each with one liter of colored water. Compare. It is easy to estimate volume accurately? In addition, the dimensions of the containers can be measured and the volumes can be calculated.

4. Have the students design a menu and kitchen for a restaurant that is converting to the metric system.

5. Conduct a metric recipe contest and compile the recipes into a booklet.

6. Simulate a metric store and help students envision the effects of metric conversion.

7. Examine labels on food products. Calculate the percentage of labels containing metric units. Are the symbols correct? Is the degree of accuracy appropriate for the product? Has the product been through the "hard conversion" phase?

8. Have students measure their heights in centimeters and masses (weights) in kilograms. Compare with averages on a metric height-mass chart. Discuss the relationship to nutrition.

Clothing and Textiles

1. Every clothing teacher has a favorite construction project—apron, hat, bag. Measure the dimensions of the object in centimeters and convert the project to metric.
2. Design metric scale gauges or guides for the sewing machines.
3. Simulate clothing purchases in metric units. What units are needed? What are the new sizes? Compare to purchasing items with our present sizing systems. Advantages? Disadvantages?
4. Construct a garment using only metric units of measurement.
5. Investigate where metrics are now being used in clothing and textiles. Interview people who are or will be affected by the changeover.

Home Furnishings

1. Estimate and then measure the dimensions of the classroom in meters. Calculate the amount of floor and wall covering that would be needed to redecorate the room.
2. Draw a floor plan to metric scale.
3. Investigate the changes in house design, house buying and decorating that will occur as metrication takes place.
4. Brainstorm the impacts of metric conversion on the environment.

General (could be applied to many subject matter areas)

1. Plan a metric scavenger hunt. Metric measurements such as "one meter" could be given and students would find an object with that dimension. Or, objects could be listed, such as "height of the counter," and students could find that length.
2. Put up signs around the department indicating distances and dimensions in metric units for others to see.
3. Have students teach someone else to use metric measurements and report the results.
4. Have a metric guessing contest: the mass of a cup of flour, the length of a piece of thread, the volume of liquid in a bottle, the temperature outside.
5. Conduct an attitude survey in your school about the change to metrics. Tabulate and report the results.
6. Interview people who have lived in countries that use the metric system. Was is difficult for them to change systems? Was the metric system easy to learn? What is their attitude about the change to metrics in the United States?
7. Develop a metric game, skit, display, simulation, movie or video tape.
8. Organize a metric club.
9. Conduct a metric workshop for parents or other people.

REFERENCES AND RESOURCES

Chapter 8 contains a list of resources which are numbered consecutively. The following numbers are helpful home economics references: 2, 3, 4, 6, 10, 13, 16-18, 23, 26, 28, 35, 41-47, 63, 74, 79, 81, 82, 84, 86 and 87.

CHAPTER 7

Metrics in Industrial Arts, Trade and Industrial, and Technical Education

J. Russell Kruppa and Fred J. Smith

INTRODUCTION

The move to metric usage in the industrial sector of the economy is more rapid than in many other sectors. Since industrial education programs must be coordinated with industry and interpret its functions, it is important that industrial educators begin to plan for this change. Within industry, the rate of metric change will vary among technologies as it will vary in school systems. For example, the construction industry has been slower to convert than has the manufacturing industry, and this is reflected in technical programs. Some school districts offer comprehensive metric programs at all levels, others provide introductory offerings and still others are not yet involved with metrics in any way.

The purpose of this chapter is to present information related to metric conversion in industrial arts, trade education and training for the technologies. The organization of the chapter is necessarily general in order to accommodate the broad range of teaching specialities it represents. The reader is invited to examine it carefully and draw upon those features that are appropriate for a given curriculum area. While the coverage is incomplete because of space limitation, sufficient information is present to permit a person to get started. The extensive bibliography presented in the final chapter is structured to help the reader identify additional resources that can be used to construct a quality metric teaching/learning program.

INSTRUCTIONAL STRATEGIES

The primary goal in metric teaching is to help students to "think metric," and to use it correctly. To aid in this process, an effort can be made to identify common referents such as body measurements, items carried in the purse or pocket and objects common to daily living. These examples may be helpful: The width of the nail on the small finger is approximately one centimeter (1 cm); the diameter of a wire in a paper clip or the thickness of a dime is about one millimeter (1 mm); the thickness of a quarter is approximately two millimeters (2 mm); a nickel is about two centimeters (2 cm) in diameter; a classroom door is roughly one meter (1 m) wide, as is the height of the door knob from the floor; the height of a regular door is approximately two meters (2 m); a quart of oil is about 3 tablespoons less than one liter (1 L) and has a mass (weight) of about one kilogram (1 kg); water freezes at zero degrees Celsius (0°C) and boils at one hundred degrees Celsius (100°C). Other referents of a personal nature will also be helpful, such as the width and span of your hand, length of your shoe, length of your stride, span of your arm reach, girth of your waist and neck, your height in centimeters and your mass in kilograms.

Instructors should teach only the essential metric units related to a particular technical area, such as the meter and millimeter in woodwork. While the SI metric system includes seven base units, two supplementary units and many derived units, most industrial and technical teachers will use only a limited number of these units in their areas of specialization. It is important to provide hands-on experience in addition to learning the appropriate units of measure and their symbols. A range of activities are suggested, such as measuring, estimating, doing metric exercises and making applications.

Caution should be exercised in selecting metric learning materials because many items are too costly for the amount of educational return. A variety of instructional strategies should be considered, such as the use of bulletin boards and other types of displays; field trips to observe the application of metrics on the job in industries; utilization of audio-visual materials such as charts, slides and tapes, filmstrips, movies, video tapes and overhead transparencies, each of which can be either commercially obtained or locally developed and learning activities that require direct application of metric measurement, such as the fabrication of products.

Conversions between metric and the inch-pound measures should be avoided or kept to a minimum. On the other hand, conversions within the system are important for the learner to become efficient in converting from one unit to another by multiplying or dividing by a power of 10 and to become familiar with replacement sizes.

Finally, it is important that the teacher become familiar with metric units by beginning to use them. Design and make a metric bookshelf; turn a metal object on a lathe, using metric measuring tools; perform metric calculations and sketch some metric project ideas. Then translate these personal experiences into learning activities for the students. For example, a simple woodworking project drawing can be supplied to students, along with appropriate measuring tools. They can make the project, thus learning something about the tools and materials and reading metric drawings. Such simplified experiences are easy to work into a course outline at a minimum cost. Each teacher should establish a personal goal of planning a short metric learning experience for students and do it *now*.

STANDARDS

As America becomes a metric nation, it uses engineering and product standards established by the International Organization for Standardization (ISO), which develops standards consistent throughout the world. These standards will reflect occasional modifications made by the American National Standards Institute (ANSI). The present inch-pound material sizes will gradually change as the metric standards become available.

At present, some metric items such as threaded fasteners and metal materials are available, which teachers should make an effort to locate and use. Obtain these from suppliers who specialize in metric stock. Instructors should refer to literature published by organizations such as the American National Metric Council, ANSI and technical societies in order to keep abreast of new standards developments. Some of these references are listed in Chapter 8.

Meanwhile, before many of the metric-sized materials are readily available, students can produce products to metric measurements by using materials that are sized to inch-pound specifications. Products can and should be designed

metrically by referring to appropriate standards tables. The practice of numerically converting old product sizes to metric (soft conversion) should be avoided.

A selection of typical metric standards is found in Figures 7-1 to 7-3. Information on additional standards is presented in Chapter 8.

Figure 7-1
Metal Thickness Measures

mm	inch
1.20	0.0472
1.00	0.0394
0.80	0.0315
0.60	0.0236
0.50	0.0197
0.40	0.0157
0.30	0.0118
0.25	0.0098
0.20	0.0079
0.16	0.0063

Selected metric thicknesses for ferrous and nonferrous metal sheet material. Gauge numbers are not used. The inch equivalents are given for reference purposes only, and are not included in the standard.

Figure 7-2
SI Metric Threads

Diameter mm	Pitch mm	Tap Drill mm	Diameter mm	Pitch mm	Tap Drill mm
M 1.6	0.35	1.25	M 20	2.5	17.50
M 2	0.40	1.60	M 24	3.0	21.00
M 2.5	0.45	2.05	M 30	3.5	26.50
M 3	0.50	2.50	M 36	4.0	32.00
M 3.5	0.60	2.90	M 42	4.5	37.50
M 4	0.70	3.30	M 48	5.0	43.00
M 5	0.80	4.20	M 56	5.5	50.50
M 6	1.00	5.00	M 64	6.0	58.00
M 8	1.25	6.75	M 72	6.0	66.00
M 10	1.50	8.50	M 80	6.0	74.00
M 12	1.75	10.25	M 90	6.0	84.00
M 14	2.00	12.00	M 100	6.0	94.00
M 16	2.00	14.00			

Standard for metric coarse threads. Metric thread pitch indicates the distance between tooth crests. Note that tap drill sizes are calculated by subtracting the pitch from the diameter.

Figure 7-3
Plywood Panel Sizes

Width mm	Length mm
1200	1800
1200	2400
1200	2700
1200	3000
1200	3600
900	2400

Standard for plywood panel sizes. The 4′ × 8′ sheet is replaced by a 1200 × 2400 mm size.

TOOLS, MACHINES, AND EQUIPMENT

A survey and evaluation of all measurement sensitive tools and equipment should be conducted for each laboratory to determine replacement or modification costs and to develop a replacement schedule. Linear measuring devices such as rules, drafting scales, micrometers, pressure and temperature gauges and mass (weight) scales must be replaced eventually. Begin by purchasing the measuring tools needed to start a modest teaching program.

Opinion varies regarding the purchase and use of dual-reading tools, such as a tape graduated in both inches and millimeters. The general recommendation is to secure devices with metric calibrations only, as this contributes to the goal of helping the learner to "think metric." However, budget constraints may require the purchase of dual measuring tools, and these can be used to good advantage with proper instructions. Non-measurement tools, such as hammers, screwdrivers and pliers, need not be replaced.

Heavy equipment, such as metal lathes, milling machines and welding equipment with measurement dials and gauges, will continue in service for years until normal replacement is necessary. In the interim, machine modifications can be made by purchasing retro-fit kits for changing lead screws and gears on lathes, cross slides, etc. Some of these kits are available in either dual-reading or metric only models. Some equipment can be fitted with optical and digital readout attachments for metric control and measurement functions. Retro-fitting heavy equipment will account for the major expense in the conversion process. On the other hand, for only a few dollars, the linear scales on drill presses, thickness planes or sheet metal squaring shears can be converted by applying pressure-sensitive metric tape or steel rules over, or adjacent to, existing inch scales.

Following are some examples of tool and equipment changes most frequently needed in metric conversion.

Drafting. Templates, scales and paper trimmers. A table of recommended drafting scale ratios, based on ANSI standards, is shown in Figure 7-4. The

triangular drafting scale recommended for general use in machine and architectural drawing features the following scale ratios:

1:1 and 1:10
1:100 and 1:1000
1:2
1:20 and 1:200
1:3
1:5 and 1:50.

Figure 7-4
Common Drafting Scale Ratios

Scale mm	Use
1:10000	Maps
1:2000	Surveys
1:1000	Site Plans
1:500	
1:200	Working Drawings
1:100	
1:50	
1:20	Assembly Drawings
1:10	
1:5	Detail Drawings
1:3	
1:2	
1:1	

Metalworking. Steel rules, combination squares, micrometers, vernier calipers, dial indicators, feeler thickness gauges, thread gauges, screw plates, thermometers, pyrometers, measurement scales on drill presses and sheet metal equipment, mass (weight) scales, drills and welding and hydraulic pressure gauges. Retro-fit kits are available for most machines. The graduations on steel rules should be to the nearest 0.5 (half) mm.

Woodworking and Building Construction. Rules, tapes, squares, drills, boring tools, mortising chisels, and scales on jointers, planers and drill presses. Rules and tapes should be graduated to the nearest millimeter. Do not use centimeter rules.

Graphic Arts and Printing. Cutters, trimmers, press feeder adjustments, layout table scales, rules, folders and volume, pressure, and temperature gauges. Most photographic equipment is already metric.

Power, Energy, Transportation. Metric automotive tools and equipment are already found in most shops. Inch-pound tools will continue in use for some time. Feeler, spark gap and temperature gauges are needed. Torque wrenches should read in newton-meters, tire-pressure gauges in kilopascals. Box and end wrenches, socket-wrench sets and volume containers are required.

Plastics. Most tool and equipment needs parallel those used in wood and metalworking. Special items include gauging on extrusion, compression, injection and vacuum molding equipment. Temperature and pressure gauges must be changed.

Electricity-Electronics. Few changes, except for rules, tapes, drills and similar hand tools.

SAMPLE TEACHING ACTIVITIES

Every technical area will feature metric learning activities in common with other areas, as well as unique applications. Some schools may find it practical to offer a brief overview of metrics to students as they enter a curriculum. As they move to different laboratories, those metric applications unique to that area should be covered. This approach is most effective if all teachers do a satisfactory job at this introductory level and especially if students arrive with some metric knowledge. Students who have a proper introduction to metrics are more confident and the teacher's task of planning meaningful learning activities is made easier.

Samples of various introductory activities that can be used in specific technical areas are provided in this section. In every case, the teacher should consider the use of a textbook that includes correct metric information. Other supplementary materials are found in Chapter 8 of this guide. Instructors already possess many excellent learning activities they have used in the past. Obviously, they should be encouraged to modify these appropriately so that they feature metric measures. The examples shown below are suggestions that can be modified to meet the requirements of many technical teaching activities.

Drafting. Scale reading is an important metric application in drafting. The learning activity in Figure 7-5 provides an introduction to this skill.

Figure 7-5
Drafting Activity

Activity	Answer
a. Use 1:5 scale ratio	
_____	_____mm
b. Use 1:1 scale ratio	
_____	_____mm
c. Use 1:2 scale ratio	
_____	_____mm
d. Use 1:1000 scale ratio	
_____	_____m

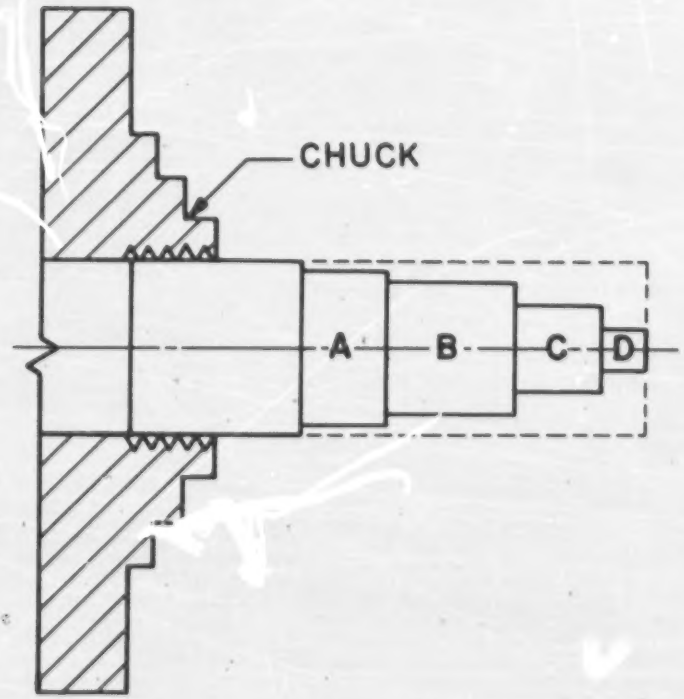
Measure the lines shown. Use the proper scale and give the reading asked for. Write your answers at the end of each line.

Metalworking. Simple machine shop activities offer excellent hands-on metric experiences in using the rule, micrometer and vernier caliper. Do the lathe turning exercise shown in Figure 7-6.

Figure 7-6
Lathe Turning Activity

Directions:

a. Mount 1″ × 3″ CRS stock in chuck. (Use 25 × 72 mm stock if available.)
b. Face end.
c. Make cut "A" Ø 20.5 mm × 10.0 mm.
d. Make cut "B" Ø 15.0 mm × 20.0 mm.
e. Make cut "C" Ø 10.0 mm × 10.0 mm.
f. Make cut "D" Ø 6.0 mm × 6.0 mm.
Tolerance: ±0.5 mm in length and diameter



Graphic Arts and Printing. Metric experiences in graphic reproduction can be conveniently approached through simple measuring and project printing activities. "Metric" paper can be made by trimming customary inch sheets.

1. Perform the following metric measurement tasks.
   a. Temperature of a developing solution _____ °C.
   b. Area of an aluminum offset plate _____ mm^2
   c. Width of paper web _____ mm
   d. Mass (weight) of roll of paper _____ kg
   e. Dimensions of A-4 paper _____ × _____ mm

2. Study the illustration in Figure 7-7 and design and print a similar business card. Use size A8 paper (52 × 74 mm).

Figure 7-7
Graphic Arts Activity

Center for Metric Education
and Studies

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Woodworking and Building Construction. Although metric conversion in this technical area may be slow, it is important to plan introductory activities for students. The following examples suggest approaches to be taken.

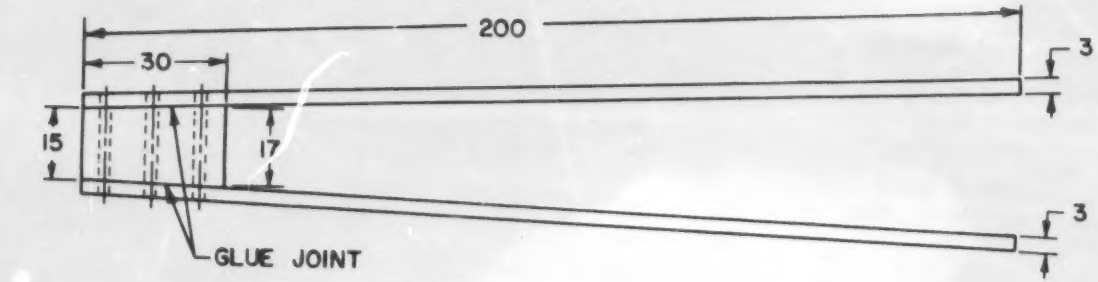
1. Study the drawing in Figure 7-8 and make the project using metric materials and measuring tools. Prepare a bill of materials for the object.

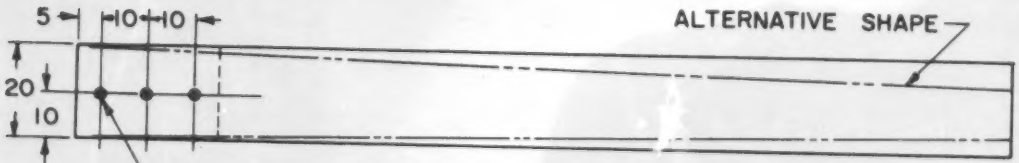
2. Calculate the amount of concrete needed for a brick wall footing which measures 150 mm thick, 450 mm wide and 6 m long.

3. Determine the number of 1200 × 2400 mm plywood panels needed to cover a roof measuring 4.8 × 8.4 m.

4. A wall 9 m long and 2.6 m high is to be plastered to an average thickness of 10mm, and the density of the plastic is 2400 kg/m^3.
   a. What is the volume of the plaster? _____.
   b. What is the mass (weight) of the plaster? _____.

Figure 7-8
Woodworking Activity





SHOP TONGS
MAT: BIRCH OR MAPLE
DIM IN mm

OTHER TONG SHAPES CAN BE USED FOR SALAD SERVERS OR ICE CUBES

5. The formula for the transmission of heat from an area of high temperature to an area of low temperature is:

$$Q = \frac{kA(\Delta T)}{t} \cdot \text{watts}$$

where k = heat conductivity of the material ($W/m \cdot °C$)
A = cross sectional area of material (m^2)
ΔT = temperature change (°C)
t = thickness of material (m)

Question: What is the heat loss in watts through a wall 2400 × 3000 mm, if the inside temperature is 20 °C and the outside temperature is 3 °C? The wall has a transfer coefficient of 1.363 and a thickness of 250 mm.

Power/Energy/Transportation. Because conversion activity is extensive in this field, metric experiences are especially appropriate.

1. With the diameter of an engine or fluid cylinder given in centimeters find the circular area by using the formula:

$$\text{area} = 0.7854\ d^2$$

2. With the bore and stroke of an engine or fluid cylinder given in centimeters, find the displacement (volume) of the cylinder using the formula:

$$\text{displacement} = 0.7854\ d^2 \times \text{stroke}.$$

3. Given the displacement of a specified engine in cubic centimeters, determine the displacement of the engine in liters. (1 liter = 1000 cm^3).

4. Determine the approximate volume in liters of a fuel tank or a lubrication or cooling system when the capacity is given in gallons. (1 gallon = 3.8 liters).

5. Measure the torque of an engine head bolt in newton-meters.

6. Measure an identified engine clearance specification with the appropriate metric gauge and record the result in millimeters as shown by the gauge.

7. Measure a specified section of an engine part with a metric micrometer and express the dimension orally or in writing to an accuracy of 0.01 mm.

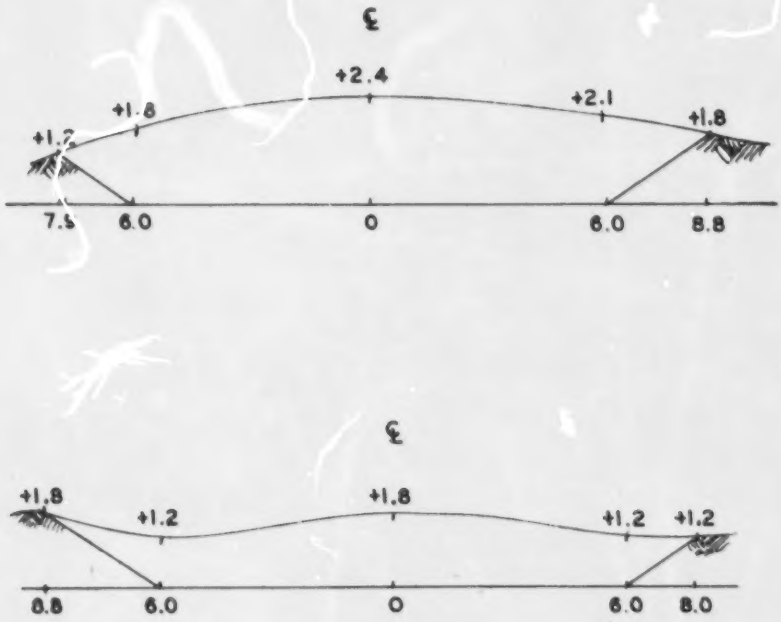
8. Determine the amount of energy expended in joules when the amount of work done is given in newton meters.

Engineering Technology. Metric conversion applications in this general area are broad and varied. Study these examples for some possible activity ideas.

1. The SI unit of force is the newton: $N = kg \cdot m/s^2$
   $f = ma$, where:
   f = force necessary to impart an acceleration to a mass (N)
   m = mass of object being accelerated (kg)
   a = acceleration imparted to the mass by the force (m/s^2)
   a. What is the force necessary to accelerate a mass of 30 kg to 13 m/s^2?
   b. What is the resultant acceleration of a mass of 50 kg acted upon by a force of 115 N?

2. The two cross-sections shown in Figure 7-9 were plotted from a surveyor's data. The sections were taken 30 meters apart, with side slopes of 1.5:1. Calculate the cubic meters of material that is to be removed.

Figure 7-9
Engineering Technology Exercise



REFERENCES AND RESOURCES

The following resources will be helpful to instructional and administrative personnel in the areas of industrial arts, trade and industrial education and technical education: 1, 4, 5, 6, 11, 15-22, 26-29, 48-64, 67-78, 80, 83, 84, 86, 89 and 91. (See Chapter 8.)

CHAPTER 8

Metric Learning and Teaching Resources

The resources listed in this chapter have been screened for metric accuracy and propriety by the persons who prepared this guide. While these references may not be totally free of error, they are recommended as valuable to the reader in the search of information and teaching materials.

There are few resources available for some technical subject areas, such as agriculture. In these situations, teachers and administrators must be constantly alert for new references as they emerge in journals or conference proceedings. They also may wish to encourage their professional societies to organize special committees to study metric needs and to prepare appropriate guides similar to that for the business education area, Reference 34. Related information can be gleaned from study documents emerging from other subject areas such as business, distributive education and transportation technology. Each of these has some relevance to agriculture and agribusiness programs. Readers are advised to peruse regularly the professional journals, technical bulletins, and supply catalogs in their subject areas for current information.

The identification numbers at the end of each chapter in this guide refer to the resources in the following list.

PUBLICATION		SOURCE
SI Metric Training Guide. (1979). Reference for planning metric training programs in industry.	(1)	American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($3.00)
Metrication and the Consumer. Planning for Practical Metric Packaging. (1978). Information on metric package sizes.	(2)	American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($1.00)
Metric Editorial Guide. (1978). Basic style guide..	(3)	American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($1.75)
Metric Guide for Educational Materials. (1977). Style guide and information for educators and writers.	(4)	American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($1.50)
Metric Conversion Papers. A series of timely monographs on topics pertinent to metric conversion.	(5)	American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($2.50)

PUBLICATION	SOURCE
Sector Plans and Summaries. ANMC Committees are continually developing sector conversion plans. Write for information on available plans and prices.	(6) American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014
Metric Reporter. Bi-weekly reference newsletter with current information on metrication.	(7) American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 ($50.00/year)
U.S. Metric Association Newsletter. Quarterly newsletter presents current reference information on metrication. Write for a list of publications.	(8) U.S. Metric Association 10245 Andasol Avenue Northridge, CA 91325 ($7.00/year)
Metric Units of Measure and Style Guide. (1976). Editorial handbook for writing SI metrics. Use for classroom, self-instruction, and reference.	(9) U.S. Metric Association Sugarloaf Star Route Boulder, CO 80302 ($1.00)
Metric Style Guide. (1975). Publication covering base units, rules of usage, special features of metric units, and other valuable information for educators.	(10) Council of Ministers of Education 252 Bloor Street West Suite 5000 Toronto, Ontario, M5S 1V5 Canada ($4.00)
Metric Style Manual—SI. by Howard M. Faulkner. (1977). A style guide for written and computer usage.	(11) International Information Systems Box 292 Gorham, ME 04038 ($2.50)
Metric Yearbook. Comprehensive annual reference report on metric conversion in America.	(12) J. J. Keller & Associates, Inc. Neenah, WI 54956 ($25.00)
Metric Reference Package. Contains a number of metric references, including a conversion chart, pocket card, color chart of the modernized metric system, and other information.	(13) United States Metric Board Suite 600 1815 North Lynn Street Arlington, VA 22209 (Free)
Metric Information Services. Write for current metric information, special publications, and research reports.	(14) United States Metric Board Suite 600 1815 North Lynn Street Arlington, VA 22209

PUBLICATION	SOURCE
Preferred Metric Units for General Use by the Federal Government. (1978). Reference guide to appropriate units.	(15) National Bureau of Standards Washington, DC 20234 (Free)
Metric Educaton Grant Program. Write for information relative to applications, regulatory materials, and other program related materials.	(16) U.S. Department of Education Metric Education Program 400 Maryland Avenue Washington, DC 20202 (Free)
Metrics for Vocational Education. (1977). A series of self-instruction or classroom booklets for a variety of vocational occupations. May be purchased as a total set or individual titles. Each booklet covers basic metric units plus those specific to the occupation.	(17) The National Center for Research in Vocational Education Ohio State University 1960 Kenny Road Columbus, OH 43210 ($2.00 each)
Metric Education—A Position Paper for Vocational Education. (1975). Reference covers issues and instructional strategies. Bibliography also available.	(18) THe National Center for Research in Vocational Education Ohio State University 1960 Kenny Road Columbus, OH 43210
Metric In-Service for Industrial Arts Teachers, by AIAA Metric Committee. (1976). Reference book with suggestions for in-service training.	(19) American Industrial Arts Association 1201 16th Street, NW Washington, DC 20036 (Free)
Metric Speakers Bureau, by AIAA Metric Committee. (1979). Reference listing of metric experts for consulting, in-service training, and workshops.	(20) American Industrial Arts Association 1201 16th Street, NW Washington, DC 20036 (Free)
A Bibliography of Metric Standards. (1977). Listing of standards for materials fasteners, and devices.	(21) American National Standards Institute 1430 Broadway New York, NY 10018 (Free)
Implementing Metric Measurement Units in Career Education, by Joseph Pokorney. (1975). Self-instruction booklet on metrics in occupational areas such as drafting, nursing, and the building trades, for classroom use.	(22) Engineering Technology, Inc. 503 East Main Street Mahomet, IL 61853 ($6.50)

PUBLICATION	SOURCE
The Metric PAL-Programmed Assigned Learning, by Jesse Wallace. (1976). Self-instructional booklet on basic metrics with application to everyday living.	(23) Jesse D. Wallace 1078 East 5th Avenue Chico, CA 95926 ($4.00)
Learning and Teaching The Metric System of Measuring—A Handbook, by King and King. (1979). A comprehensive approach to learning and teaching metrics.	(24) Allyn and Bacon, Inc. 470 Atlantic Avenue Boston, MA 02210 ($10.36)
SI Metric Handbook, by John L. Feirer. (1978). Thorough treatment of metrics in areas from agriculture to industry to family living. Well-illustrated reference, which includes information on standard conversion of machines.	(25) Chas A. Bennett Co., Inc. 809 West Detweiller Drive Peoria, IL 61615 ($25.00)
Metrics in Career Education, by John R. Lindbeck. (1975). A guide for people teaching industrial students in high schools and technical institutions.	(26) Chas A. Bennett Co., Inc. 809 West Detweiller Drive Peoria, IL 61615 ($3.50)
A Guide to Metrics, by Terry Richardson. (1978). Self-instruction book supplemented with charts and other data.	(27) Prakken Publications, Inc. 416 Longshore Drive Box 8623 Ann Arbor, MI 48107 ($12.00)
Measuring Up: Mastering Metrics for the World of Work, by Pamela Cuming. (1978). Programmed textbook for adult workers and managers.	(28) Addison-Wesley Publishing Company Reading, MA 01867 ($7.00)
Construction and Agricultural Equipment Sector Plan. (1978). Planning guide to metric conversion in this equipment sector.	(29) American National Metric Council 1625 Massachusetts Avenue, NW Washington, DC 20036 (Free)
Use of SI (Metric) Units: ASAE EP 285.4. (1979). Engineering practice guide for agriculture.	(30) American Society of Agricultural Engineers 2950 Niles Road St. Joseph, MI 49085 ($5.00)

PUBLICATION	SOURCE
Metrics for Vocational Education-Agri-Business Areas. (1977). Booklets cover the areas of horticulture; agricultural supplies and services; agricultural mechanics; and forestry.	(31) The National Center for Research in Vocational Education 1960 Kenny Road Ohio State University Columbus, OH 43210 ($2.00 each)
Metrics in Agriculture. (1979). Planning package and standards data. Write for information on availability and prices.	(32) Metric Commission Canada Ottawa, Ontario K1A OH5 Canada
Think Metric in Business Education. (1976). Teachers reference guide to metrics in business education.	(33) Illinois Business Education Association Olney Central College Olney, IL 62450 ($1.50)
The Metric System in Business Education, edited by Lila Prigge. (1979). A reference guide for the business teacher covering skills and teaching strategies.	(34) National Business Education Association 1906 Association Drive Reston, VA 22091 ($4.50)
Going Metric—What's in Store for Consumers. (1977). Overview of metric changes in consumer products.	(35) Consumers Union of the United States, Inc. Mount Vernon, NY 10550 ($2.00)
A Look at Metrics in Distributive Education, by Robert A. Canai. (1977). A teacher's reference for distributive education.	(36) Ohio Distributive Education Material Lab 115 Townshed Hall Ohio State University Columbus, OH 43211 ($3.50)
Medicine and Metrication, by Howard M. Faulkner. (1977). Overview of metric units and practices for the medical fields.	(37) International Information Systems Box 292 Gorham, ME 04038 ($2.50)
Medical Device Sector Conversion Plan. (1978). Strategies for metric conversion in the medical sector, including tables and discussion of appropriate units.	(38) American National Metric Council 5410 Grosvenor Lane Bethesda, MD 20014 (Free)

PUBLICATION	SOURCE
The SI for the Health Profession, by The World Health Organization. (1977). A comprehensive report on metrics in medicine and health.	(39) United Nations Bookshop United Nations Building New York, NY 10017 ($7.50)
SI Units in Medicine, by Herbert Lippert. (1978). An overview of metrics in medicine with extensive conversion tables.	(40) Urban and Schwarzenberger, Inc. 7 East Redwood Street Baltimore, MD 21202 ($14.50)
Moving to Metrics, by Judy Oppert. (1977). Teachers reference guide to metric conversion.	(41) Home Economics Education Association 1201 Sixteenth Street, NW Washington, DC 20036 ($2.50)
Handbook for Metric Usage. (1978). Basic information on metrics in home economics	(42) American Home Economics Association 2010 Massachusetts Avenue, NW Washington, DC 20036 ($6.00)
Guidelines for Metrication. (1979). Reference resource for metric standards and terminology in sewing.	(43) American Home Sewing Association, Inc. 350 Fifth Avenue New York, NY 10001 ($5.00)
Hometrics, by Lorelle Young and Carole Bielefeld. (1977). A general introduction to SI, stressing metrics in the home. Good reference with classroom applications.	(44) Crown Education and Teacher's Store 318 Riggs Road Washington, DC 20036 ($4.95)
Educator's Guide to Metric for Clothing Construction. (1976).	(45) Coats and Clark, Inc. Box 1010 Toccoa, GA 30577 ($0.50)
American Beef Cookbook. (1976). Guide to metric recipes and techniques.	(46) Beef Industry Council National Livestock and Meat Board 444 N. Michigan Avenue Chicago, IL 60611 ($2.50)

PUBLICATION	SOURCE
Handbook of Food Preparation. (1980). General metric information related to preparing foods.	(47) American Home Economics 2010 Massachusetts Avenue, NW Washington, DC 20036 ($8.50)
General Motors Drafting Standards. (1980). Metric drafting standards for corporate use, with yearly revisions.	(48) General Motors Engineering Standards Section General Motors Technical Center Warren, MI 48090 ($35.00)
Metric System (SI) in Engineering Technology, by Antonin Martinek. (1977). An overview of metric units, instruments and standards in technology.	(49) Metric Engineering, Inc. Box 2515, Postal Station B Kitchener, Ontario N2H 6M3 ($8.75)
Reference Handbook for the Proper Usage of Metric SI in Science and Engineering. (1974). Metric practice guide for reference or on-the-job training.	(50) Robert C. Sellers and Associates Box 99 Floral Park, NY 11002 ($2.10)
Metric Units in Engineering—Going SI, by Cornelius Wandmacher. (1978). Comprehensive reference for engineering and technology.	(51) Industrial Press, Inc. 200 Madison Avenue New York, NY 10016 ($25.00)
World Metric Standards for Engineering, by Knut Kverneland. (1977). Comprehensive engineering reference materials.	(52) Industrial Press, Inc. 200 Madison Avenue New York, NY 10016 ($47.50)
An American National Standard ASTM/IEEE Standard Metric Practice. (1979). Primary guide to metric conversion in engineering and technology.	(53) Institute of Electrical and Electronics Engineers, Inc. 345 East 47th Street New York, NY 10017 ($5.00) **OR** American Society for Testing and Materials 1916 Race Street Philadelphia, PA 19103 ($5.00)

PUBLICATION	SOURCE
Metric Units for Fluid Power Applications. (1978). Reference book including a brief description of the metric system, definitions and units used in fluid power.	(54) National Fluid Power Association 333 North Mayfair Road Milwaukee, WI 53222 ($5.50)
Aluminum Standards and Data Metrics SI. (1978). Reference information covering properties, quality control, nomenclature, standards for sheet, plate tubing, pipe, wire, rod, and forgings.	(55) The Aluminum Association 818 Connecticut Avenue, NW Washington, DC 20006 (Free)
Metric Practice Guide for the Welding Industry. (1975). A guide for the welding industry in converting to SI units.	(56) American Welding Society 2501 Northwest 7th Street Miami, FL 33125 ($3.50)
Metric Practice Guide: Units and Conversion Factors for the Steel Industry. (1975). Technical reference for iron steel industries.	(57) American Iron and Steel Institute 1000 Sixteenth Street, NW Washington, DC 20036 ($5.00)
Manufacturing Processes SI Version, by B. H. Amstead, et. al. (1979). Current textbook features, metric measures and charts.	(58) John Wiley and Sons, Inc. One Wiley Drive Somerset, NJ 08873 ($25.00)
Guide to Metric Fasteners. (1976). Reference information describing metric fasteners, sizes, types, fits, conversion factors, and torque specifications, etc.	(59) Lawson Products, Inc. 1666 East Touhy Avenue Des Plaines, IL 60018 (Free)
ISO Metric Screw-Thread Manual. (1974). Reference manual detailing specifications for ISO fasteners.	(60) Greenfield Tap and Die Sanderson Street Greenfield, MA 01301 ($1.25)
Lumber and Wood Products Metric Planning Package. (1978). A progress report of conversion activities in the forest products industry. Lists standards likely to be adopted, and suggestions for in-plant training of personnel.	(61) National Forest Products Association 1619 Massachusetts Avenue, NW Washington, DC 20036 (Free)

PUBLICATION	SOURCE
Metric Manual for Wood Products. (1978). Reference includes metric sizes for lumber, panel products, windows, and doors, poles, and shingles.	(62) Canadian Wood Council 170 Laurier Avenue West Ottawa, Ontario, KLP 5V5 Canada ($5.00)
Recommended Practice for the Use of Metric (SI) Units in Building Design and Construction, by Hans Milton. (1977). Reference guide to metric units in the construction industry.	(63) National Bureau of Standards Washington, DC 20234 ($1.60)
Metalwork—SI Metric Edition, by John L. Feirer and John R. Lindbeck. (1979). Reference textbook for use in metalworking.	(64) Chas. A. Bennett Co., Inc. 809 West Detweiller Drive Peoria, IL 61615 ($9.96)
Metric Practices in Drafting, by John R. Lindbeck. (1979). Workbook for use in drafting.	(65) Chas. A. Bennett Co., Inc. 809 West Detweiller Drive Peoria, IL 61615 ($2.64)
Metric Drafting, by Paul Wallach. (1979). Comprehensive drafting textbook. Workbook also available for classroom.	(66) Glencoe Publishing Company, Inc. 17337 Ventura Boulevard Encino, CA 91316 ($16.60)
Technical Drafting: Metric Design and Communication, by Michael B. Atkins and William P. Spence. (1980). A totally metric technical textbook covering the basic industrial draft-area. Current metric standards and drafting procedues are included.	(67) Chas. A. Bennett Co., Inc. 809 West Detweiller Drive Peoria, IL 61615 ($13.95)
Going Metric With the U.S. Printing Industry, by Clive A. Cameron. (1973). This reference book covers metric conversion, and standards for printing equipment, paper, and packaging.	(68) Graphic Arts Research Center Rochester Institute of Technology One Lomb Memorial Drive Rochester, NY 14623 ($8.70)
America Goes Metric. (1974). Metric conversion reference guide for the printing industry.	(69) Nekoosa Edwards Paper Company, Inc. Port Edwards, WI 54469 ($3.00)

PUBLICATION	SOURCE
(70) **Representations for U.S. Customary SI, and Other Units to Be Used in Systems with Limited Character Sets.** (1976). American National Standard ANSI X3.50-1976	American National Standards Institute 1430 Broadway New York, NY 10018 ($4.00)
(71) **Catalog** of scientific devices and tools, including metric.	Edmund Scientific Company 380 Edscorp Building Barrington, NJ 08007 (Free)
(72) **Catalog** of metric measuring instruments, tools, supplies, charts, and other audio visual items.	Stanley Tools 480 Myrtle Street New Britain, CT 06050 (Free)
(73) **Catalog** of metric hardward and software items for graphic arts.	Dick Blick Company Box 1267 Galesburg, IL 61401 (Free)
(74) **Catalog** of hardware and software supplies for teaching metrics.	Creative Publications 3977 East Bayshore Road Box 10328 Palo Alto, CA 94303 (Free)
(75) **Catalog** of metric conversion dial wheels for lathes, mills and other machines.	SIPCO Machine Company Barnabas Road Marion, MA 02738 (Free)
(76) **Catalog** of tools, equipment, and supplies for vocational education, including metric.	Broadhead Garrett 4960 East 71st Street Cleveland, OH 44105 (Free)
(77) **Catalog** of metric tools and fasteners.	Reid Tool Supply 2233 Temple Street Muskegon Heights, MI 49440 (Free)
(78) **Catalog** of metric tools, fasteners, and conversion devices.	Zelenda Machine and Tool Corporation 66-02 Austin Street Forest Hills, NY 11734 (Free)

PUBLICATION	SOURCE
Catalog of metric measuring utensils and equipment for the kitchen.	(79) Foley 3300 NE Fifth Street Minneapolis, MN 55418 (Free)
Catalog of metric drafting equipment, tools, and supplies.	(80) Teledyne-Post 700 Northwest Highway Des Plaines, IL 60016 (Free)
Measuring Metric in Fashion Sewing. (1976). Sound filmstrip on metrics in clothing classroom. Instructor guide included.	(81) Education Department The McCall Pattern Company 230 Park Avenue New York, NY 10017 ($15.00)
Education and Metrics, by Howard Faulkner. (1976). Contains over 200 transparency masters for teacher in-service and student instruction in metrics for daily living.	(82) Visual Products Division 3M Center St. Paul, MN 55101 ($98.00)
Taking the Tricks Out of Metrics. (1976). Four helpful programmed instruction booklets for self-instruction and classroom use. **#1 How to Read a Metric Micrometer.** **#2 How to Read a Metric Vernier Caliper.** **#3 How to Read Metric Rules and Tapes.** **#4 How to Read a Metric Dial Indicator.**	(83) Creative Universal, Inc. Suite 1200, Tower 14 21700 Northwest Highway Southfield, MI 48075 ($2.75 each)
Going Metric in Industrial Education. (1974). Seven packages of instructional materials for areas such as drafting metals, and home economics. Contains self-instruction program plans, and charts. Materials also for Spanish speaking students, slow learners, and the blind.	(84) Center for Metric Education and Studies Western Michigan University Kalamazoo, MI 49008 (Packages available at university industrial education departments in each state.)
A Metric America. (1975). Through animation, this 16-minute film describes metric units and most frequently used prefixes. Good for use with students, teachers, or parents.	(85) Aims Instructional Media Service, Inc. Box 1010 Hollywood, CA 90028 ($8.00 rental)

PUBLICATION	SOURCE
Metrics for Career Education. (1976.) Six sound filmstrips covering woodworking, home economics, general metals, machine shop, power and energy, and drafting in the classroom.	(86) Encyclopedia Britannica Educational Corporation 425 N. Michigan Avenue Chicago, IL 60611 ($106.95/set; may be ordered separately)
Metrics in the Kitchen. (1977). Teacher's audio-visual package for the classroom, including student handouts and oven stickers.	(87) General Mills, Canada Ltd. Box 505 Rexdale, Ontario M9W 4X4 Canada ($35.00)
This Business of Metrics, by Lila Prigge and Judith Lambrecht. (1978). Multimedia package utilizing tapes and workbooks to provide an introduction to SI.	(88) Western Tape Publishing Company 2761 Marine Way Box 61 Mountain View, CA 94042 ($75.00/set; units may be ordered separately)
SI (metric), by R. Lam, F. Shalabi, and R. Taylor. (1978). Student and instructor workbook. Activities for metric training in secondary and post secondary education.	(89) Holland College Charlottetown Centre Clearinghouse Prince Edward Island, C1A 4Z1 Canada
Make It Metric, by Gladys Earl, Anita Pershern and Anita Wilson. (1979). Food laboratory manual to provide experience in using the metric system, and to demonstrate principles of food science.	(90) Burgess Publishing Company 7108 Ohms Lane Minneapolis, MN 55435 ($9.95)
Metric Building and Construction Guide, edited by Susan Braybrooke. (1980). A primary guide to metric conversion in construction.	(91) American Institute of Architects 1735 New York Avenue, NW Washington, DC 20006 ($19.95)